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Alaska Department of Fish and Game
Division of Commercial Fisheries
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Anchorage, Alaska 99518

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Sonar Estimation of Fall Chum Salmon Abundance In the Sheenjek River, 2002

by

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State of Alaska Frank Murkowski, Governor

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ABSTRACT

Bendix Corporation[2] fixed-location, single-beam sonar was used to estimate chum salmon, *Oncorhynchus keta* escapement in the Sheenjek River August 9 - September 24, 2002. The sonar-estimated escapement was 31,642 chum salmon, 37 % below the low end of the Sheenjek River biological escapement goal (BEG) of 50,000 to 104,000 chum salmon. Median passage was observed on September 10; peak single day passage was September 19 when 2,006 fish were estimated passed the sonar site. As in some previous years, a slight bimodal entry pattern was observed. A diel migration pattern showed most chum salmon passed the sonar site during periods of darkness or suppressed light. Range of ensonification was considered adequate for most fish, which passed near shore. However, the passage estimate should be considered conservative since it does not include fish migrating beyond the counting range (including along the unensonified far bank), fish present before sonar equipment was in operation, or fish passing after counting ceased. Analysis of vertebrae collections showed age-4 fish dominated at 61% and age-5 fish represented 39% of all fish sampled. Male chum salmon comprised 63% of the sample and 37% were female. Only 35 vertebrae samples were collected because of low salmon passage.

A new split-beam system developed by Hydroacoustic Technology, Incorporated (HTI) was tested side-by-side with the currently used Bendix sonar. The HTI sonar was used to estimate chum salmon passage in the Sheenjek River from August 14 through September 22, 2002. Comparison of passage estimates shows the HTI system produces similar results to the Bendix sonar; therefore, it can be used to upgrade the current system.

KEY WORDS: Chum salmon, *Oncorhynchus keta,* sonar, hydroacoustics, escapement, enumeration, Yukon River, Porcupine River, Sheenjek River

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[2] Reference to trade names does not imply endorsement by the Alaska Department of Fish and Game.

INTRODUCTION

Five species of anadromous Pacific salmon *Oncorhynchus spp.* are found in the Yukon River drainage. Chum salmon, *O. keta,* are the most abundant and occur in genetically distinct summer and fall runs (Wilmot et al. 1992; Seeb et al. 1995). Fall chum salmon are larger, spawn later, and are less abundant than summer chum salmon. Spawning occurs in upper portions of the drainage in spring fed streams, usually remaining ice-free during the winter (Buklis and Barton 1984). Major fall chum salmon spawning areas occur within the Tanana, Chandalar, and Porcupine River systems, and portions of the upper Yukon River in Canada (Figure 1).

Inriver Fisheries

Fall chum salmon are in great demand for commercial and subsistence uses. Commercial harvest is permitted along the entire mainstem river in Alaska and in the lower portion of the Tanana River. No commercial harvest is permitted in any other tributaries of the drainage including the Koyukuk and Porcupine River systems. Although commercial harvest occurs in the Canadian portion of the Yukon River near Dawson, most fish are taken commercially in the lower river, downstream of the village of Anvik. Subsistence use of fall chum salmon is greatest throughout the upper river drainage, upstream of the village of Koyukuk.

Although the Alaskan commercial fishery for Yukon River fall chum salmon developed in the early 1960s, annual harvests remained relatively low through the early to mid-1970s. Estimated total inriver utilization (U.S. and Canada commercial and subsistence) of Yukon River fall chum salmon was below 300,000 fish per year before the mid-1970s (Table 1). Inriver commercial fisheries became more fully developed during the late 1970s and early 1980s, total utilization averaged 536,000 fish from 1979-1983. Harvest peaked in 1979 at 615,000 and in 1981 at 677,000 fish. Since the mid-1980s, management strategies have been implemented to reduce commercial exploitation on fall chum stocks to improve low escapements observed throughout the drainage during the early 1980's. In 1987, the commercial fall chum fishery was completely closed in the Alaskan portion of the drainage. In 1992, commercial fishing in Alaska was restricted to a portion of the Tanana River during the fall season. In addition to a commercial fishery closure, 1993 marked the first year a total closure to subsistence fishing in State history occurred in the Yukon River. The closure was in effect during the latter portion of the fall season in response to the extremely weak fall chum salmon run.

Yukon River fall chum salmon runs improved somewhat from 1994 through 1996. In 1994, limited commercial fishing was permitted in the Alaskan portion of the upper Yukon River, and in the Tanana River. Commercial fishing was permitted in all districts throughout the Alaska portion of the drainage in 1995. In 1996, limited commercial fishing was only permitted in selected districts of the mainstem Yukon River; no commercial fishing was permitted in the Tanana River. Poor salmon runs to Western Alaska from 1997 to 2002 resulted in partial or total closures to commercial and subsistence fishing in Alaskan and Canadian portions of the drainage. Commercial fishing was only permitted in the Tanana River and Canada in 1997. A total commercial fishery closure and limited subsistence fishing was required in 1998. Limited commercial harvest was permitted in 1999, and a total commercial fishery closure and severe subsistence fishing restrictions was required in 2000, 2001 and 2002.

Escapement Assessment

During the period 1960 through 1980, only some segments of Yukon River fall chum salmon runs were estimated from mark-and-recapture studies (Buklis and Barton 1984). Excluding these tagging studies, and apart from aerial assessment of selected tributaries since the early 1970s, comprehensive escapement estimation studies were sporadic and limited to only two streams, the Delta River (Tanana River drainage) and Fishing Branch River (Porcupine River drainage). In the early 1980s, comprehensive escapement assessment studies intensified on major spawning tributaries throughout the drainage.

Fisheries and Oceans Canada (DFO) estimated abundance of fall chum salmon crossing the US/Canada border in the mainstem river into Yukon Territory annually since 1982 (excluding 1984) using mark-and-recapture techniques (Milligan et al. 1984, JTC 2002). In addition, DFO reinstalled a weir in the Fishing Branch River in 1985. The weir, which previously operated from 1971 through 1975, has monitored chum salmon escapements to the river annually since 1985, excluding 1990.

In the Alaskan portion of the drainage, the United States Fish and Wildlife Service (USFWS) estimated annual fall chum salmon escapement to the Chandalar River from 1986 through 1990 using fixed-location, single-beam hydroacoustic techniques (Daum et al. 1992). Results from this project revealed fall chum salmon production was similar to that of the nearby Sheenjek River. Subsequently, in 1994, the USFWS initiated a five-year study to reassess the population status of fall chum salmon with a newly developed split-beam hydroacoustic system. The initial year, 1994, was used to develop site-specific operational methods, evaluate site characteristics, and describe possible data collection biases (Daum and Osborne 1995). The project was again operated in 1995 and was fully operational from 1996 through 2002. Annual escapement estimates ranged from a low of 65,894 in 2000 to a high of 280,999 in 1995 (Osborne and Melegari 2002, JTC 2002).

The Alaska Department of Fish and Game (ADF&G) initiated an experimental main river sonar project near Pilot Station (rivermile 123) in 1978, to estimate salmon passage by species. During the developmental years of 1978 through 1985, data acquisition and sampling designs were investigated using various models of scientific fisheries hydroacoustic systems. The project has operated annually since 1986, except for 1992 when it was operated for experimental purposes with upgraded sonar equipment and 1996 when it was operated for training purposes only. However, because of recent improvements in methodologies, historic data are not comparable to improved assessments available since 1995 (JTC 1999). In addition to the Pilot Station sonar project operated by ADF&G, USFWS has conducted a mark-and-recapture project annually since 1996 at an area known locally as "The Rapids", a narrow canyon near Rampart, 1,176 kilometers from the mouth of the Yukon River. The purpose of this project is to provide abundance estimates of adult fall chum salmon bound for the upper Yukon River (Gordon et al. 1998, Underwood et al. 2000).

ADF&G has conducted annual mark-and-recapture studies in the Tanana River since 1995 to estimate abundance of fall chum salmon bound for the upper river, upstream of the Kantishna River (Cleary and Hamazaki 2003). ADF&G also conducts replicate ground surveys of upper Tanana River drainage fall chum spawning areas in the Delta River. Intensive ground surveys annually cover the major spawning area in the upper Toklat River. Total abundance estimates are derived from the Toklat and Delta surveys, using spawner residence time data collected from the Delta River (Barton 1997, JTC 2002). Hydroacoustic assessment of fall chum salmon escapement in the Toklat River was investigated in 1994, 1995, and 1996 (Barton 1998). The Toklat River sonar project was reinstated in 2001, but in 2002 budget constraints and concerns about data quality prevented operation (P. Cleary, Alaska Department of Fish and Game, personal communication).

One of the most intensely monitored spawning streams in recent years has been the Sheenjek River. Although escapement observations date back to 1960 when USFWS reported chum salmon spawning in September, the best database consists of 28-years, 1974-2001. Before 1981, escapement observations in the Sheenjek River were limited to aerial surveys flown in late September and early October (Barton 1984a). Subsequent to 1980, escapements were monitored annually using fixed location single beam side looking sonar systems (Dunbar 2002). However, an early segment of the fall chum salmon run was not included by sonar counting operations from 1981 through 1990 because late project startups centered on August 25. By comparison, average startup during the period 1991 through 2001 was August 8, more than two weeks earlier than previous years. The sonar-estimated escapements for the years 1986 through 1990 were subsequently expanded to include fish passing before sonar operations (Barton 1995). Termination of sonar counting was consistent during the period 1981 through 2001, averaging September 24, except in 2000 when the project was terminated early because of extremely low water (Barton 2002). This report presents the results of studies conducted in 2002.

Bendix Sonar Replacement

The Sheenjek River sonar project has used Bendix sonar equipment to estimate migrating chum salmon escapement since 1981. Although the Bendix sonar worked well over the years, it is no longer in production and the company provides no support for the system. The Department purchased an HTI model 241 split-beam digital echo sounder sonar system for use on the Sheenjek River to continue providing the best possible data to manage fisheries. In 2000, the new system was tested for a short time and produced results comparable to the Bendix equipment. This report presents results of studies conducted in 2002.

Study Area

The Sheenjek River is one of the most important producers of fall chum salmon in the Yukon River drainage. Located above the Arctic Circle, it heads in glacial ice fields of the Romanzof Mountains, a northern extension of the Brooks Range, and flows southward approximately 400 km to its terminus on the Porcupine River (Figure 2). The sonar project site is located approximately 10 km upstream from the mouth of the river. Although created by glaciers, the river has numerous clearwater tributaries. Water clarity in the lower river is somewhat unpredictable, but is generally clearest during periods of low water. The water level normally begins to drop in late August and September. Upwelling ground water composes a significant proportion of the river flow volume, especially in winter. Fall chum salmon spawn in these spring areas, particularly within the lower 160 km of the river.

Annual escapement estimates averaged 106,000 spawners for the period 1986-1995 and approximately 42,000 spawners for the most recent 5-year period of 1997-2001. From 1992 to 2000 the Sheenjek River minimum biological escapement goal (BEG) established was 64,000 fall chum salmon, based upon hydroacoustic assessment from 1974 to 1990 (Buklis 1993). In 2001, the department completed a review of the escapement goal for Yukon River fall chum stocks of which the Sheenjek River assessment is a component. Based on this review of long term escapement, catch, and age composition data, the BEG for the Sheenjek River was set at a range of 50,000 to 104,000 fall chum salmon (Eggers 2001).

Objectives

Goals for the 2002 Sheenjek River fall chum salmon study were to estimate the timing and magnitude of adult salmon escapement, characterize age and sex composition, and to compare passage estimates of the new HTI model 241 split-beam digital echo sounder to those of the Bendix system. To accomplish these tasks, these specific objectives were identified:

- Estimate timing and magnitude of chum salmon escapement using Bendix fixed-location single-beam side looking hydroacoustic techniques.
- Estimate age and sex composition of the spawning population from sampled portions of the escapement using a beach seine as capture technique.
- Monitor selected climatological and hydrological parameters daily at the project site for use as baseline data.
- Locate a suitable deployment site for the new split-beam sonar.
- Deploy and operate the HTI system side by side with the Bendix system.

- Compare the HTI sonar passage estimates with the Bendix sonar and visual tower estimates.

METHODS

Bendix Hydroacoustic Equipment

A fixed-location, single-beam, fisheries hydroacoustic system developed by the Hydrodynamics Division of Bendix Corporation was used to estimate chum salmon abundance in the Sheenjek River in 2002. Fish passage was monitored with a 1985-model transceiver and transducer deployed from a right-bank[3] point bar at the historic sonar site (Figures 3 and 4).

Bendix side-looking transducers have co-axial, circular cross-section narrow (2°) and wide (4°) beam dimensions. Sampling ranges for the narrow and wide beams are each variable to 30 m but designed for optimum performance at 18.3 m and 9.1 m, respectively. The transceiver can be operated on either narrow or wide beam independently, or by alternating acoustic pulse transmissions between the two beams. In the latter mode (that used on the Sheenjek River), narrow and wide beams monitor fish passage in outer and inner halves of the sampling range, respectively.

The transceiver maintains a record of spatial distribution of fish estimates based upon distance of the acoustic target from the transducer. Fish estimates were tallied and stored into dynamic memory by 16 equal range intervals or sectors. A tape printout showing the number of tallies (counts) by sector was printed each hour. The transceiver was designed such that 24 counts in any one electronic sector in a 35-second period are not necessarily fish. Under such conditions, the system operator is alerted by the presence of a "debris" code appearing on the printout tape next to suspect counts for the sector and hour in which they occurred. Examples of factors that can result in "debris counts" appearing on printout tapes include, passage of debris through the ensonified water column, boat wakes, driving rain, snowfall, misaimed beam toward river bottom or water surface, high density of fish passage, and holding or spawning fish. In addition, a "rock inhibit" feature was designed into this counter to facilitate the system operator in maintaining aim of the acoustic beam as close to the natural bottom substrate as possible.

While other operational characteristics of Bendix hydroacoustic systems and procedures can be found in Bendix Corporation (1978) and Ehrenberg (undated), the 1985-model transceiver used in 2002 was modified after production to allow the system operator to lower the pulse repetition rate to a level not previously possible. This alteration was implemented to better accommodate relatively slow chum salmon swimming speeds (A. Menin, Hydroacoustic Consulting, Sylmar, California, personal communication). This modification has increased the system operator's ability to reduce the degree of positive bias associated with over-counting.

[3] Right bank refers to the bank on the right when looking downstream.

HTI Hydroacoustic Equipment

An HTI hydroacoustic system was operated in conjunction with the Bendix system at the historic Sheenjek River sonar site in 2002. The HTI system consists of an HTI model 241 digital echo sounder (Appendix A) and a 2°X10° 200 kHz split-beam transducer. Attached to the transducer was an HTI model 662H dual-axis rotator with an HTI model 660 remote controller to facilitate aiming. The HTI system is capable of distinguishing upstream fish from downstream fish and debris, determine fish velocity, discriminate between random reverberation and fish targets, and provide a less biased estimate of target strength (Hydroacoustic Technology Incorporated 2000).

The HTI digital echo sounder is a state-of-the-art system designed for fisheries research. Highly accurate time-varied gains (TVG's) and very stable transmit and receive sensitivities are possible. Short pulse widths can be used to improve resolution between targets. A Digital Echo Processor (DEP) is integrated into the system. A laptop computer paired with the sounder provides access to all the DEP settings and permits saving settings for future use. An oscilloscope can be linked to the sounder for diagnostic use, such as in-situ system calibration or transducer aiming. After all parameters are determined for data acquisition, the system operates 24 hours a day. Files are created by the DEP and edited to produce an estimate of fish passage.

Site Selection and Transducer Deployment

The modular aluminum substrate designed for use with Bendix sonar systems has not been used on the Sheenjek River since 1984, because of the salmon avoidance problems observed when the substrate was in use (Barton 1985). The relatively gentle-sloping river bottom and small cobble at the historic counting location has allowed operation without the aluminum substrate. A detailed bottom profile was obtained after initial transducer placement at the counting location by stretching a rope across the river and measuring water depth with a pole every 3-m (Figure 5). The Bendix transducer was mounted on a pod made of galvanized steel pipe (Barton 1997) and deployed from the right-bank point bar. The pod was secured in place with sandbags and designed to permit raising and lowering of the acoustic beam by using two riser pipes that extend above the water. Fine adjustments were made with knurled knobs that attached the transducer plate to the pod. The transducer was deployed in water ranging from approximately 0.5 to 1.0 m in depth, and aimed perpendicular to the current along the natural gravel substrate. An attempt was made to ensure the transducer was deployed at locations where minimum surface water velocities did not fall below 30-45 cm/s. The HTI transducer and automatic rotator was mounted on an aluminum pod secured with sandbags about 1.5m up-river and about 0.7m inshore of the Bendix transducer. Aim adjustments were made using the remote control for the automatic rotator.

The system operator used an artificial acoustic target during deployment to ensure transducer aim was low enough to prevent salmon from passing undetected beneath the acoustic beam. The target, an airtight 250 ml weighted plastic bottle, was allowed to drift downstream along the river bottom and through the acoustic beams. Several drifts were made with the target in an attempt to pass it through each electronic sector of the Bendix sonar counting range and to ensure the full counting range of the HTI transducer was covered as well. When the transducer was properly aimed, the target appeared as a vertical deflection (spike) on an oscilloscope screen as it transected the acoustic beam at a given distance. Proper aim for the HTI system was verified with visual interpretation (echogram) on a computer screen as well as the oscilloscope. The target may or may not have simultaneously registered a count (or multiple counts) on the sonar counter, depending upon the length of time it remained in the acoustic beam as it drifted downstream along the river bottom. Later in the season, a 1.5-inch tungsten carbide sphere was used to verify how close to the bottom we could detect the target.

As in previous years, a fish lead was constructed shoreward from the transducers to prevent upstream salmon passage inshore of the transducers. Fish leads were constructed using 5 cm x 5 cm by 1.2-m high galvanized chain-link fencing and 2.5 m metal "T" stakes. Leads were constructed to include the near-field "dead range" of the sonar transducers. Whenever a transducer was relocated because of rising or falling water level, the inshore lead was shortened or lengthened as appropriate, and the artificial target used to ensure proper re-aiming. A 5-m aluminum counting tower was also deployed near the transducers to facilitate visual and electronic calibrations when water conditions permitted.

Bendix Sonar Calibrations and Count Adjustments

Daily comparisons (calibrations) were made between oscilloscope observations and automated counter output to determine if the number of fish registered by the sonar counter equaled the number of fish observed passing through the acoustic beam. A minimum of six, 15 to 30 minute calibrations were targeted each day within the following time periods: 0001-0100 hours; 0300-0400 hours; 0600-0700 hours; 1100-1200 hours; 1600-1700 hours; and 2100-2200 hours. Duration of calibrations was based upon the following criteria: 1) stop calibration at 15 minutes if less than 10 fish are observed; and, 2) extend 15-minute calibration to 30 minutes if 10 or more fish are observed in the first 15 minutes.

Calibration results were used to adjust automated passage estimates daily for positive or negative bias. Adjustment periods were defined by the time between individual calibrations. An associated adjustment factor (A), specific to each adjustment period (i) was calculated as follows:

$$A_i = \frac{OC_i}{SC_i} \tag{1}$$

where:

OC_i = oscilloscope count; and,
SC_i = sonar count for adjustment period

Unadjusted hourly sonar passage estimates were multiplied by adjustment factors for each hour within the associated adjustment period. The resulting corrected hourly sonar estimates were summed, yielding the estimated daily passage ($\hat{D}$) of fall chum salmon, and is calculated as

$$\hat{D} = \sum (A_i SC_i \ ) \qquad (2)$$

Sonar counts caused by fish other than salmon were assumed insignificant based upon historic test fishing records collected at the site. Counts identified as "debris" on printout tapes were deleted and replaced by linearly interpolated values before making adjustments. Linear interpolation was also used to estimate missing sector counts caused by occasional printer malfunctions. Interpolated values for a given electronic sector were based upon registered counts for that sector in the preceding and following hour. Missing hourly blocks for a given day, resulting from powering down the sonar counter to relocate the transducer or operations-tent caused by changes in water level, were estimated by interpolation using average hourly passage rates from hours just before and after the missing period. If a known portion of an hour of data is missing, passage for that hour was estimated by expansion.

Adjustments to the pulse repetition rate (PRR) or ping rate of the sonar counter were made to minimize over-counting (positive bias) or under-counting (negative bias). Over or under counting primarily results from changes in salmon swimming speeds that may be related to fluctuations in water level and velocity, photoperiod, or fish densities (Barton 1995). Although a few occasions arose when the ping rate was subjectively changed based upon a qualitative evaluation of fish passage rates, the ping rate was generally changed at the end of any calibration when the oscilloscope count exceeded 59 per hour and differed by more than 15% from the sonar count. The new ping rate was calculated as the sonar count divided by oscilloscope count, times the current PRR setting. If passage rates during calibrations on any given day never exceeded 59 fish per hour, the ping rate was changed at 2400 hours of that particular day. However, this change was made only if the sum of sonar counts during all of the day's calibrations differed from the sum of oscilloscope counts from all calibrations by more than 15%. Otherwise, the dial setting was left unchanged.

HTI Sonar Count Adjustments

At the end of each day, data collected by the DEP in 24 hourly text files was transferred to another computer for tracking and editing. To facilitate tracking, echoes from stationary objects were removed using a custom program created in *C* computer language (Appendix B). The filtered echoes were then grouped into tracks using the *Alpha-Beta Tracker,* auto-tracking software developed by Mr. Peter Withler through a cooperative agreement with the DFO, ADF&G and HTI. The *Alpha-Beta Tracker* implements tracking algorithms described in *Multiple-Target Tracking with Radar Applications* (Blackman 1986). The tracked data was manually edited to remove spurious tracks, such as those from remaining bottom, using *Polaris,* an echogram editor also developed by Mr. Peter Withler through the same cooperative agreement. The edited data was saved to a *Microsoft Access* database. Hourly estimates from the database were exported to a *Microsoft Excel* spreadsheet where linear interpolation was used for hours of missing data. If data from a complete hour was missing, counts were interpolated by averaging counts from two hours before and two hours after the missing hour. If two complete hours were missing, counts were interpolated by averaging counts from three hours before and three hours after the missing hours. If three hours were missing, counts were interpolated by averaging counts from four hours before and four hours after the missing hours. If four or more hours were missing, counts were interpolated by averaging counts from five hours before and five hours after the missing hours. When a portion of an hour was missing, passage was estimated by expansion based on the known portion of the hour. Sixty minutes was divided by the known number of minutes counted (if 10 min. or more) and then multiplied by the number of fish counted in that period. Visually counting fish from the tower proved impossible during most of the season because of wind, glare, murky water, and fish avoidance.

Stationary Bottom Removal

Echoes from stationary objects were removed before tracking by dividing data into range bins (0.2 meters), calculating the moving average (averaging window of 1,000 echoes) of the voltage in each range bin and then removing the echo if the voltage was within 1.7 standard deviations of the mean and at least 100 echoes were within that range bin. The echo was not removed if the percentage of missed echoes relative to observed echoes was greater than 80. The percentage of missed relative to observed echoes was calculated by summing differences between observed ping numbers minus one and then dividing by the total number of echoes in the range bin.

Auto Tracking

After the data was cleaned up with the bottom removal program, the *Alpha Beta Tracker* automatically selected groups of echoes considered fish based on parameters selected by the operator. These echoes are grouped into fish tracks that can be enumerated to produce an estimate of fish passage. Tracking parameters include alpha and beta values for X, Y, Z (position estimates), minimum echoes per track, maximum missed pings and search radius. Alpha and beta Parameters were determined by manually tracking about 50 fish in *Polaris* and choosing values that minimized the squared differences between observed and predicted positions.

Final Editing

Final editing was accomplished with *Polaris*. Potential filters included mean target strength, pulse width, standard deviation of residuals, median velocity, and mean -12 dB pulse width. Values for the filters were determined by comparing histograms of the filter parameters for tracked fish and for non-fish groups of echoes. Filtered fish tracks were viewed and edited if necessary. Missed fish tracks were added manually and erroneous tracked echoes were manually removed. After all editing was complete, the data was imported to an *Access* database and an *Excel* spreadsheet where the final estimate of hourly and daily fish passage was produced.

Test Fishing and Salmon Sampling

Region wide standards have been set for the sample size needed to describe the age composition of a salmon population. These standards apply to the period or stratum in which the sample is collected. Sample size goals are based on a one-in-ten chance (precision) of not having the true age proportion (p_i) within the interval $p_i \pm 0.05$ for all i ages (accuracy).

Based upon age determination from scales, a sample size of 160 fish per stratum is needed for chum salmon assuming two major age classes with minor ages pooled, and no unreadable scales. The preferred method of aging Yukon River fall chum salmon, when in close proximity to their natal streams, is from vertebrae collections (Clark 1986). Allowing for 20% unreadable vertebrae, the Sheenjek River sample size goal was to sample approximately 30-35 chum salmon per week up to a maximum of 200.

An adult salmon beach seine was periodically fished at different locations between the sonar site and approximately 10-12 km upstream to collect adult salmon for age and sex composition. The beach seine (3-inch stretch measure) was 30 m in length by 55 meshes deep (~3 m). The seine was dyed green, constructed of #18 twine, possessed 3x5-inch high-density, non-grommet oval poly floats spaced approximately 45 cm apart, had a 115-120 lb lead line and 1/2 in (1.3 cm) float line. Chum salmon were collected with the beach seine, enumerated by sex using external characteristics, and measured in millimeters from mid-eye to fork of tail. Additionally, one vertebra was taken from each fish for age determination.

Climatological and Hydrological Observations

A water level gauge was installed at the sonar site and monitored daily with readings made to the nearest centimeter. Surface water temperature was measured daily with a pocket thermometer. Minimum and maximum air temperatures, and wind velocity and direction were measured daily with a Weather Wizard III weather station. Other daily observations included recording occurrence of precipitation and estimating percent cloud cover. Climatological observations were recorded at approximately 1800 hours daily.

RESULTS

River and Sonar Counting Conditions

In 2002, location of transducer deployment approximated the same place on the point bar used in recent years. This site was also acceptable for the HTI transducer. The river bottom at the counting location sloped gently from the convex bank (right-bank, point bar) at a rate of approximately 11.5 cm/m (bottom slope ≈ 12%) to the shelf-break that lay approximately two-thirds of the way across the channel on August 9 (Figure 5). River width measured 47 m and much of the nearshore zone along the concave, left cutbank was cluttered with fallen trees and other woody vegetation.

The water level remained low at the project site through 2002, the lowest level recorded on September 8 (Figure 6 and Appendix C). With respect to the initial reading of the water gauge upon deployment on August 7, the water level fell 11.4 cm during the first week then gained 22.3 cm between August 14 and 18. From August 19 to September 8, the water level dropped to 22.9 cm below the initial level recorded on August 7. Between September 9 and 12 water quickly rose to 36.2 cm above the zero datum mark. The water level dropped continuously during the remainder of the project. Although the water level was 5.8 cm higher on the last day of the project than the first day, this level was still low relative to past years. Water temperature at the project site ranged from 5°C to 12°C based upon instantaneous surface measurements, and averaged 9.2°C (Appendices B).

Fluctuations in water level affected placement of the transducers with respect to shore, and in turn, the proportion of the river ensonified. While no attempt was made to estimate fish passage beyond the counting range, an expansion of sonar counts by interpolation was made to estimate fish passage for hours when raw data were missing. Missing data may occur because of unforeseen circumstances or powering down the sonar counter to facilitate repositioning the transducer in response to water level changes. The average unensonified river zone for the Bendix sonar in 2002 measured from the cutbank was about 12 m, ranging from a minimum of 11 m on August 9 to a maximum of 13 m on September 11. The unensonified zone for the HTI sonar was approximately 0.7 m less than the Bendix sonar until September 11 when both transducers were moved. From September 11 to the end of the season the unensonified zone of the HTI sonar was about 2 m less than the Bendix sonar.

Abundance Estimation

The 2002 Bendix sonar-estimated escapement was 31,642 chum salmon for the 47-day period August 9 through September 24 (Table 2 and Appendix D). During the operation, sonar counts were adjusted daily for positive or negative bias based upon oscilloscope calibrations. A total of 293 calibrations averaging 19 minutes in duration were made (Appendix E). This total was approximately 93 hours, or 8% of the total number of hours the sonar counter was functional. Technicians attempted to time calibrations to periods of the day when upstream migration was heaviest (Figure 7). For example, an average of 36% of the calibrations was made between 0001 and 0600 hours, corresponding to an average daily fish passage estimate of 35% for the same block of time. Similarly, an average of 14% of the calibrations was made between 1200 and 1800 hours, corresponding to an average daily fish passage estimate of 15% for that period.

During the first week of operation, the presence of small grayling (*Thymallus arcticus*) surfacing in front of the transducer was noted. The crew also noted seeing schools of grayling from the tower, and skiff while traveling on the river. Although these fish were a source of concern at the time, through examination of the sonar, the grayling did not appear to be counted. After about a week, this concern was resolved as the crew only saw grayling occasionally and usually only one or two at a time.

Comparison of the HTI and Bendix sonar estimates was conducted during periods of low and moderately high passage during the period August 14 to September 22. During this 40-day period, the HTI sonar upstream passage estimate was 29,839 chum salmon and the Bendix sonar estimated passage was 27,071 chum salmon (Table 3 and Figure 8). The cumulative passage estimate differed by <10% (Figure 9). Although differences in the daily HTI and Bendix sonar passage estimates were observed, the coefficient of determination is high ($R=0.864$) indicating a good relationship between the two measures (Figure 10).

Temporal and Spatial Distribution

Chum salmon were present in the river when Bendix sonar counting was initiated on August 9, as evidenced by the 602 fish estimated passing that day. Three distinct pulses of chum salmon passed the sonar in 2002 (Figure 11), the largest passage estimate of 2,006 fish occurring on September 19, coinciding with a surge of high water. The middle portion of the run was observed from August 28 through September 18, the median day of passage occurred on September 10. The average passage rate during this period approximated 773 fish per day. An estimated 769 chum salmon passed the project site on September 24, the final day of sonar sampling. Factors affecting termination of sonar counting in 2002 included declining fish passage rates, logistics associated with closing down camp, and impending winter weather.

The diel pattern of migration of Sheenjek River chum salmon typically observed in most years was again manifested in 2002 (Figure 12 and Appendix D). Upstream migration was heaviest in periods of darkness or suppressed light. On average, the period of greatest upstream migration observed with the Bendix sonar occurred between 2000 hours and 1000 hours the following day (77%), the peak occurred between the hours of 0500 to 0900 (31%). The period of least movement in 2002 was between approximately 1100 and 1900 hours (23%). The diel migration observed with the HTI sonar shows a very similar pattern (Figure 13).

Most migrating chum salmon were shore-oriented, passing through the nearshore sectors of the Bendix acoustic beam. Approximately 94% of the fish counted were estimated passing through the first 11 electronic sectors, or within approximately 20 m of the transducer. The first sector had fewer fish due to the placement of the fish lead. Approximately 6% were observed in the outermost five sectors (Figure 14). The spatial distribution observed with the HTI sonar shows a very similar pattern (Figure 15). The first two meters of the HTI sonar had fewer fish because the transducer was located about 0.7m closer to shore than the Bendix transducer.

Age and Sex Composition

Although an attempt was made to sample portions of annual escapement for age and sex composition in 2002, only 35 chum salmon (22 males; 13 females) were obtained because of distribution and availability of salmon for sampling (Table 4). Twelve seine hauls were made from August 30 through September 4 along gravel bars between river kilometers 11 and 13. Sampling with the beach seine was terminated on September 4 because the escapement estimate was very low. Of the samples collected, 32 were from the beach seine, and the remainder were from scavenged carcasses. Four of the 35 vertebrae collected were unreadable. From the remaining 31 samples, age-4 dominated (61%), and the proportion of age-5 fish observed was approximately 39%. No age-2, age-3 or age-6 fish were observed in the samples (Appendix F).

DISCUSSION

Escapement Estimate

The 2002 sonar-estimated escapement of chum salmon in the Sheenjek River is considered conservative because fish passing the site before or after sonar sampling, beyond the range of the acoustic beam and along the unensonified far bank, were not included in the estimate. Drift gillnet fishing results during the period 1981-1983 at the historic sonar sampling site demonstrated that distribution of upstream migrant chum salmon was primarily confined to the right side of the river, and only a small (but unknown) proportion passed beyond the sonar counting range (Barton 1984b). Barton (1985) further concluded from investigations in 1984 that although dispersed throughout the river well below the sonar site, upstream-migrant chum salmon orient toward the right bank before reaching the sonar sampling location. No attempt was made to estimate fish passage in the unensonified river zone in 2002. This passage is believed comparatively small based upon a review of spatial distribution of fish by electronic sector.

Although sonar has been used to monitor chum salmon escapements in the Sheenjek River since 1981, only since 1991 have the project operational dates been consistent. Barton (1995) used run timing data collected from the nearby Chandalar River to expand Sheenjek River run size estimates for the years 1986-1988, and 1990 to a comparable period. The 1989 estimate was expanded from aerial survey observations made before sonar operations in that year (Appendix G). Barton (2002) used historic run timing data from 1986 to 1999 to expand the estimated escapement for 2000, when the sonar operations terminated early.

From average run timing data for 1986-2001, approximately 85% of the Sheenjek River fall chum salmon run (through the end of September) materializes subsequent to August 25, with the middle portion of the run passing from August 30 through September 16 (Appendix H). The historical median day of passage is September 8. Although fish were present in the river early, most fish arrived later; the median passage day in 2002 was two days later than the historical average. An assumed small, but unknown portion of the Sheenjek River fall chum salmon run in 2002 passed the sonar site subsequent to sonar counting. Historical run timing data for 1986-2001 suggests approximately 5% of the run (through end of September) passed after September 23.

Barton (1995) noted sonar-estimated escapements in the Sheenjek River should be viewed in context with dates of project operation (Table 5). The escapement estimate in 2002 approximated 31,642 chum salmon for the 47-day period, August 9 through September 24. This escapement estimate is the third lowest recorded at Sheenjek River, and is not enough to meet the low end of the revised BEG of 50,000 to 104,000 chum salmon (Figure 16). The escapement estimate was not within the acceptable range, although a total closure of the Yukon River commercial fisheries and severe restrictions imposed on subsistence users was implemented. This low run was somewhat expected because the major parent year escapement levels were 80,423 in 1997 (returning age-5 fish) and 33,058 in 1998 (returning age-4 fish).

The low 2002 Sheenjek River escapement estimate was consistent with escapement trends for other upper Yukon River areas. The Chandalar River escapement was estimated at 89,847 chum salmon for the 50-day period of August 8 through September 26. Run timing characteristics were similar to those observed in the Sheenjek River (B. Osborne, USFWS, Fairbanks, personal communication). The Chandalar run was slightly bimodal, the median day of passage recorded on September 3, five days earlier than the Sheenjek River. The central half of the run was observed between August 23 and September 11. The estimated escapement in 2002 (using split beam sonar) was 22% lower than the 2001 estimate (109,829 fish), 61% below the 1995-2002 average of 147,000 chum salmon. The (BEG) has been set at 74,000 to 152,000 fall chum salmon for the Chandalar River (Eggers 2001).

Low numbers of returning fall chum salmon were also reported in the Canadian portion of the Yukon River drainage in 2002. In the Fishing Branch River, only 13,363 chum salmon passed the DFO weir during the 48-day period of August 29 through October 15 (JTC 2002). Similar to the Sheenjek River, this escapement was low, well below the interim escapement goal range of 50,000 to 120,000 fish. The 2002 estimate of spawning escapement for Canadian mainstem Yukon River fall chum salmon was approximately 86,000 fish, 43% above the minimum escapement goal of 60,000 chum salmon.

The 2002 season marked the sixth consecutive year characterized by very low salmon runs to some western Alaska river systems. Exact reasons for poor fall chum salmon runs are unknown, scientist speculate poor marine survival results from or is accentuated by localized weather conditions in the Bering Sea (Kruse 1998).

Timely reporting of daily passage estimates at the Sheenjek River project site corroborated other inseason indicators that the 2002 fall chum salmon run was extremely weak. Although some fall chum salmon BEGs were achieved within the Yukon River drainage in 2002, severe commercial and subsistence restrictions were necessary to achieve these goals.

Bendix and HTI Sonar Comparison

Passage estimates, diel and spatial distribution patterns of fall chum salmon appear very similar with the Bendix and HTI sonar systems. Overall, the cumulative HTI sonar passage estimate was <10% higher than the Bendix sonar. During periods of low salmon passage, the Bendix sonar counts were slightly higher, likely from over counting of very slow fish. At higher salmon passage, the HTI sonar counts were relatively higher. Diel patterns were similar with both systems. More fish were counted at night and periods of low light than were counted during daylight hours. Hourly fluctuations in the differences between the estimates were likely the result of fish swim speed changing between Bendix sonar calibrations. Spatial distribution was about the same with both systems. The HTI system counted a few more fish at farther range, possibly counting fish following the thalweg. Overall, the passage estimates produced by the two systems were nearly identical during this sample period. As with past years, use of a tower to visually count fish proved impossible. In the future, we recommend the HTI sonar system be used at the same location to estimate the fall chum salmon escapement in the Sheenjek River.

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Table 1. Alaskan and Canadian total utilization of Yukon River fall chum salmon, 1961-2002 (JTC 2002).

Year	Canada [a]	Alaska [b,c]	Total
1961	9,076	144,233	153,309
1962	9,436	140,401	149,837
1963	27,696	99,031 [d]	126,727
1964	12,187	128,707	140,894
1965	11,789	135,600	147,389
1966	13,192	122,548	135,740
1967	16,961	107,018	123,979
1968	11,633	97,552	109,185
1969	7,776	183,373	191,149
1970	3,711	265,096	268,807
1971	16,911	246,756	263,667
1972	7,532	188,178	195,710
1973	10,135	285,760	295,895
1974	11,646	383,552	395,198
1975	20,600	361,600	382,200
1976	5,200	228,717	233,917
1977	12,479	340,757	353,236
1978	9,566	331,250	340,816
1979	22,084	593,293	615,377
1980	22,218	466,087	488,305
1981	22,281	654,976	677,257
1982	16,091	357,084	373,175
1983	29,490	495,526	525,016
1984	29,267	383,055	412,322
1985	41,265	474,216	515,481
1986	14,543	303,485	318,028
1987	44,480	361,663 [d]	406,143
1988	33,565	319,677	353,242
1989	23,020	518,157	541,177
1990	33,622	316,478	350,100
1991	35,418	403,678	439,096
1992	20,815	128,031 [f]	148,846
1993	14,090	76,925 [d]	91,015
1994	38,008	131,217	169,225
1995	45,600	415,547	461,147
1996	24,354	236,569	260,923
1997	15,580	154,479 [f]	170,059
1998	7,901	62,869 [d]	70,770
1999	19,506	110,369	129,875
2000	9,236	19,307 [d]	28,543
2001	9,513	35,154 [d]	44,667
2002 [g]	8,008	19,677 [d]	27,685
Average			
1961-01	19,255	263,609	282,864
1992-01	20,460	137,047	157,507
1997-01	12,347	76,436	88,783

[a] Catch in number of salmon. Includes commercial, Aboriginal, domestic and sport catches combined.

[b] Catch in number of salmon. Includes estimated number of salmon harvested for commercial production of salmon roe.

[c] Commercial, subsistence, personal-use and ADF&G test fish catches combined.

[d] Commercial fishery did not operate in Alaskan portion of drainage.

[f] Commercial fishery operated only in District 6 (Tanana River).

[g] Data are Preliminary.

Table 2. Sonar-estimated passage of fall chum salmon in the Sheenjek River, 2002.

	Number of Salmon		Proportion	
Date	Daily	Cumulative	Daily	Cumulative
09-Aug	602	602	0.02	0.02
10-Aug	756	1,358	0.02	0.04
11-Aug	656	2,014	0.02	0.06
12-Aug	528	2,542	0.02	0.08
13-Aug	381	2,923	0.01	0.09
14-Aug	450	3,373	0.01	0.11
15-Aug	396	3,769	0.01	0.12
16-Aug	449	4,218	0.01	0.13
17-Aug	360	4,578	0.01	0.14
18-Aug	262	4,840	0.01	0.15
19-Aug	395	5,235	0.01	0.17
20-Aug	179	5,414	0.01	0.17
21-Aug	355	5,769	0.01	0.18
22-Aug	243	6,012	0.01	0.19
23-Aug	220	6,232	0.01	0.20
24-Aug	139	6,371	0.00	0.20
25-Aug	370	6,741	0.01	0.21
26-Aug	300	7,041	0.01	0.22
27-Aug	244	7,285	0.01	0.23
28-Aug	488	7,773	0.02	0.25 [a]
29-Aug	892	8,665	0.03	0.27
30-Aug	573	9,238	0.02	0.29
31-Aug	733	9,971	0.02	0.32
01-Sep	774	10,745	0.02	0.34
02-Sep	657	11,402	0.02	0.36
03-Sep	542	11,944	0.02	0.38
04-Sep	820	12,764	0.03	0.40
05-Sep	429	13,193	0.01	0.42
06-Sep	838	14,031	0.03	0.44
07-Sep	543	14,574	0.02	0.46
08-Sep	406	14,980	0.01	0.47
09-Sep	676	15,656	0.02	0.49
10-Sep	507	16,163	0.02	0.51 [b]
11-Sep	376	16,539	0.01	0.52
12-Sep	670	17,209	0.02	0.54
13-Sep	841	18,050	0.03	0.57
14-Sep	1353	19,403	0.04	0.61
15-Sep	923	20,326	0.03	0.64
16-Sep	1247	21,573	0.04	0.68
17-Sep	1124	22,697	0.04	0.72
18-Sep	1588	24,285	0.05	0.77
19-Sep	2006	26,291	0.06	0.83
20-Sep	1688	27,979	0.05	0.88
21-Sep	1199	29,178	0.04	0.92
22-Sep	816	29,994	0.03	0.95
23-Sep	879	30,873	0.03	0.98
24-Sep	769	31,642	0.02	1.00
Total	31,642		1.00	

[a] Single boxed area identifies central half of the run.

[b] Bold box indentifies median day of passage.

Table 3. Bendix and HTI sonar-estimated passage of fall chum salmon in the Sheenjek River August 14 through September 22, 2002.

	Bendix Number of Salmon		HTI Number of Salmon	
Date	Daily	Cumulative	Daily	Cumulative
14-Aug	450	450	289	289
15-Aug	396	846	302	591
16-Aug	449	1,295	221	812
17-Aug	360	1,655	335	1,147
18-Aug	262	1,917	196	1,343
19-Aug	395	2,312	274	1,617
20-Aug	179	2,491	243	1,860
21-Aug	355	2,846	198	2,058
22-Aug	243	3,089	224	2,282
23-Aug	220	3,309	309	2,591
24-Aug	139	3,448	224	2,815
25-Aug	370	3,818	463	3,278
26-Aug	300	4,118	418	3,696
27-Aug	244	4,362	398	4,094
28-Aug	488	4,850	567	4,661
29-Aug	892	5,742	516	5,177
30-Aug	573	6,315	791	5,968
31-Aug	733	7,048	668	6,636
01-Sep	774	7,822	748	7,384
02-Sep	657	8,479	597	7,981
03-Sep	542	9,021	855	8,836
04-Sep	820	9,841	815	9,651
05-Sep	429	10,270	616	10,267
06-Sep	838	11,108	663	10,930
07-Sep	543	11,651	596	11,526
08-Sep	406	12,057	582	12,108
09-Sep	676	12,733	636	12,744
10-Sep	507	13,240	567	13,311
11-Sep	376	13,616	547	13,858
12-Sep	670	14,286	587	14,445
13-Sep	841	15,127	618	15,063
14-Sep	1353	16,480	1,081	16,144
15-Sep	923	17,403	1,191	17,335
16-Sep	1247	18,650	1,540	18,875
17-Sep	1124	19,774	1,743	20,618
18-Sep	1588	21,362	2,133	22,751
19-Sep	2006	23,368	2,248	24,999
20-Sep	1688	25,056	2,076	27,075
21-Sep	1199	26,255	1,590	28,665
22-Sep	816	27,071	1,174	29,839
Total	27,071		29,839	

Table 4. Sheenjek River test fishing (beach seine) and carcass collection results, 2002.

Date	Number of Sets	Location (rkm)[a]	Seine Male	Seine Female	Chum Salmon Carcass's Male	Chum Salmon Carcass's Female	Total Male	Total Female	Arctic Grayling
30-Aug	3	11 & 13	1	1			1	1	42
1-Sep	3	13	6	0			6	0	23
2-Sep	2	13	0	0			0	0	5
4-Sep	4	13	12	12			12	12	8
8-Sep	0	16			1		1	0	
11-Sep	0	10			1		1	0	
22-Sep	0	19			1		1	0	
Total	12		19	13	3	0	22 (63%)	13 (37%)	78

[a] Locations are river kilometer(rkm).

Table 5. Operational dates of sonar sampling in the Sheenjek River, 1981-2002.

Year	Starting Date	Ending Date	Project Duration	Sonar Estimate	Expanded Estimate
1981	31-Aug	24-Sep	25	74,560	
1982	31-Aug	22-Sep	23	31,421	
1983	29-Aug	24-Sep	27	49,392	
1984	30-Aug	25-Sep	27	27,130	
1985	02-Sep	29-Sep	28	152,768	
1986	17-Aug	24-Sep	39	83,197 [a]	84,207
1987	25-Aug	24-Sep	31	140,086	153,267
1988	21-Aug	27-Sep	38	40,866	45,206
1989	24-Aug	25-Sep	33	79,116	99,116
1990	22-Aug	28-Sep	38	62,200	77,750
1991	09-Aug	24-Sep	47	86,496	
1992	09-Aug	20-Sep	43	78,808	
1993	08-Aug	28-Sep	52	42,922	
1994	07-Aug	28-Sep	53	150,565	
1995	10-Aug	25-Sep	47	241,855	
1996	30-Jul	24-Sep	57	246,889	
1997	09-Aug	23-Sep	46	80,423	
1998	17-Aug	30-Sep	45	33,058	
1999	10-Aug	23-Sep	45	14,229	
2000	08-Aug	12-Sep	36	18,652 [b]	30,084
2001	11-Aug	23-Sep	44	53,932	
2002	09-Aug	24-Sep	47	31,642	
Averages:					
1981-85	30-Aug	24-Sep	26	67,054	
1986-90	21-Aug	25-Sep	36	81,093	91,909
1991-01	08-Aug	23-Sep	47	95,257	96,296
1997-01	11-Aug	22-Sep	43	40,059	42,345

[a] The sonar-estimated escapement in these years was subsequently expanded to include fish passing prior to sonar operations (Barton 1995). Expansions for 1986-1988 and 1990 were based upon run timing data collected in the nearby Chandalar River. The 1989 estimate was expanded based upon aerial survey observations made in the Sheenjek River prior to sonar operations in that year.

[b] The sonar-estimated escapement was expanded to include fish passing after sonar operations terminated (Barton 2002). Expansions for 2000 were based upon average run time data from the Sheenjek River 1986 - 1999.

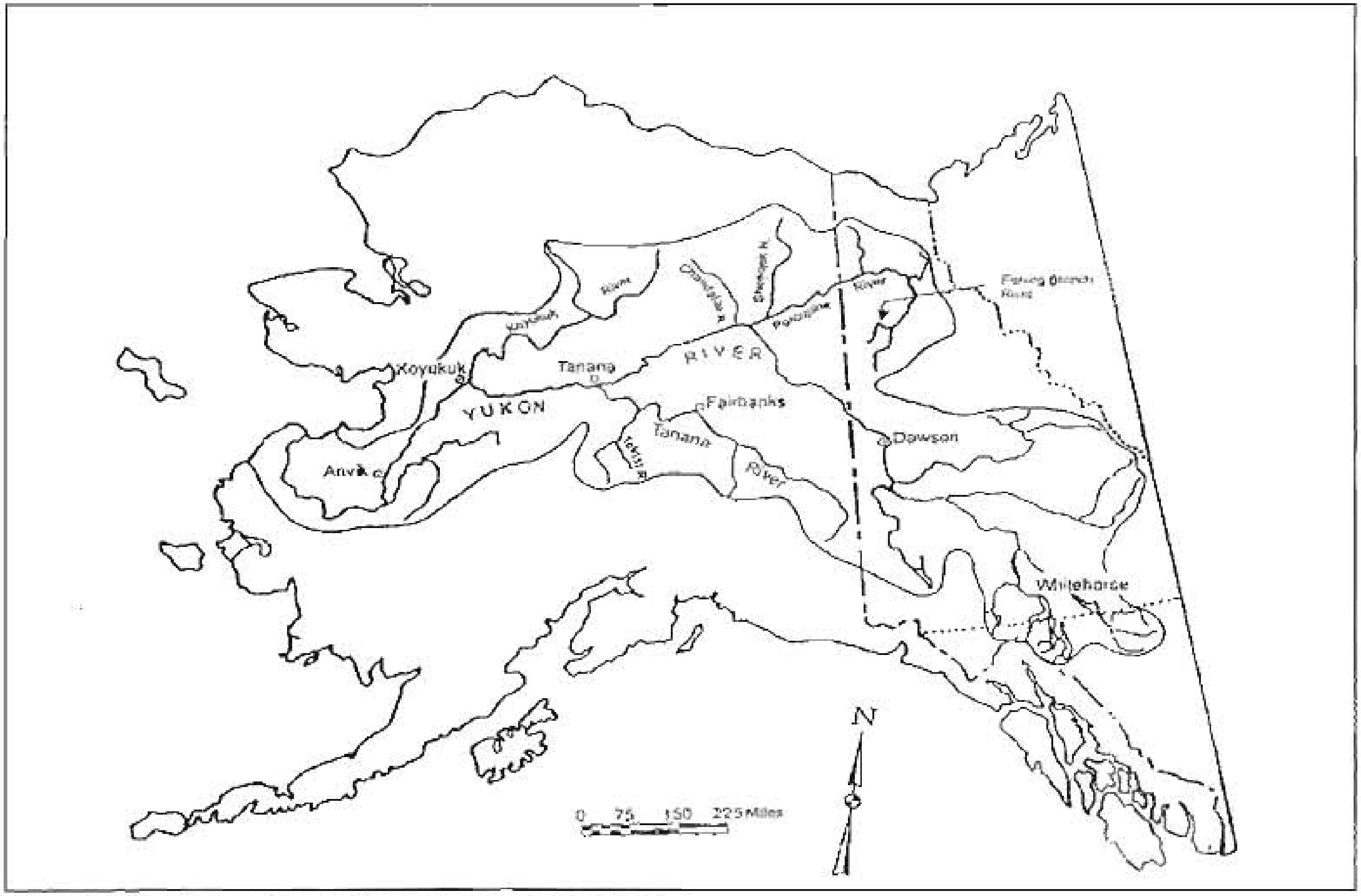

Figure 1. The Yukon River drainage showing selected locations.

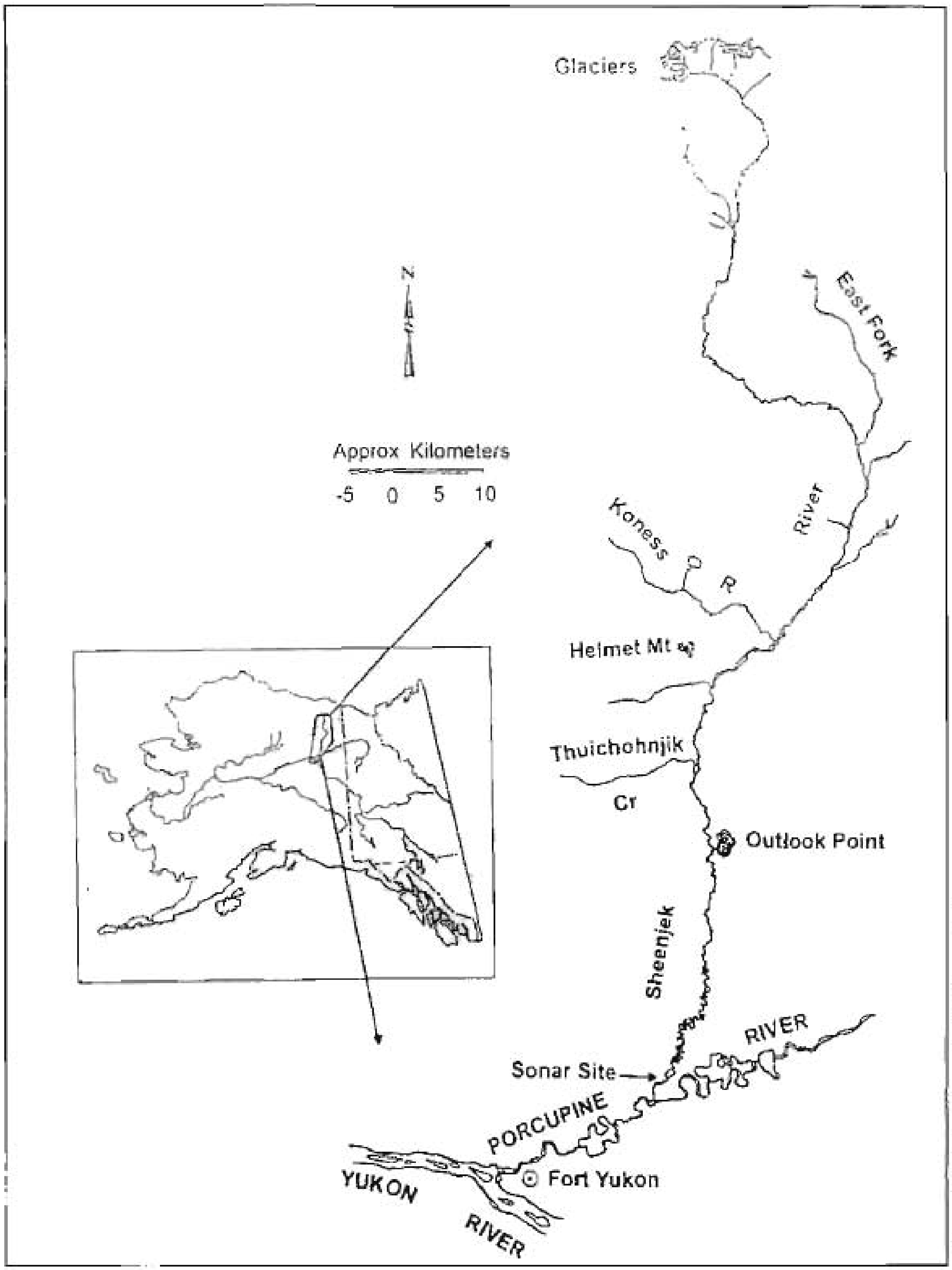

Figure 2. The Sheenjek River drainage.

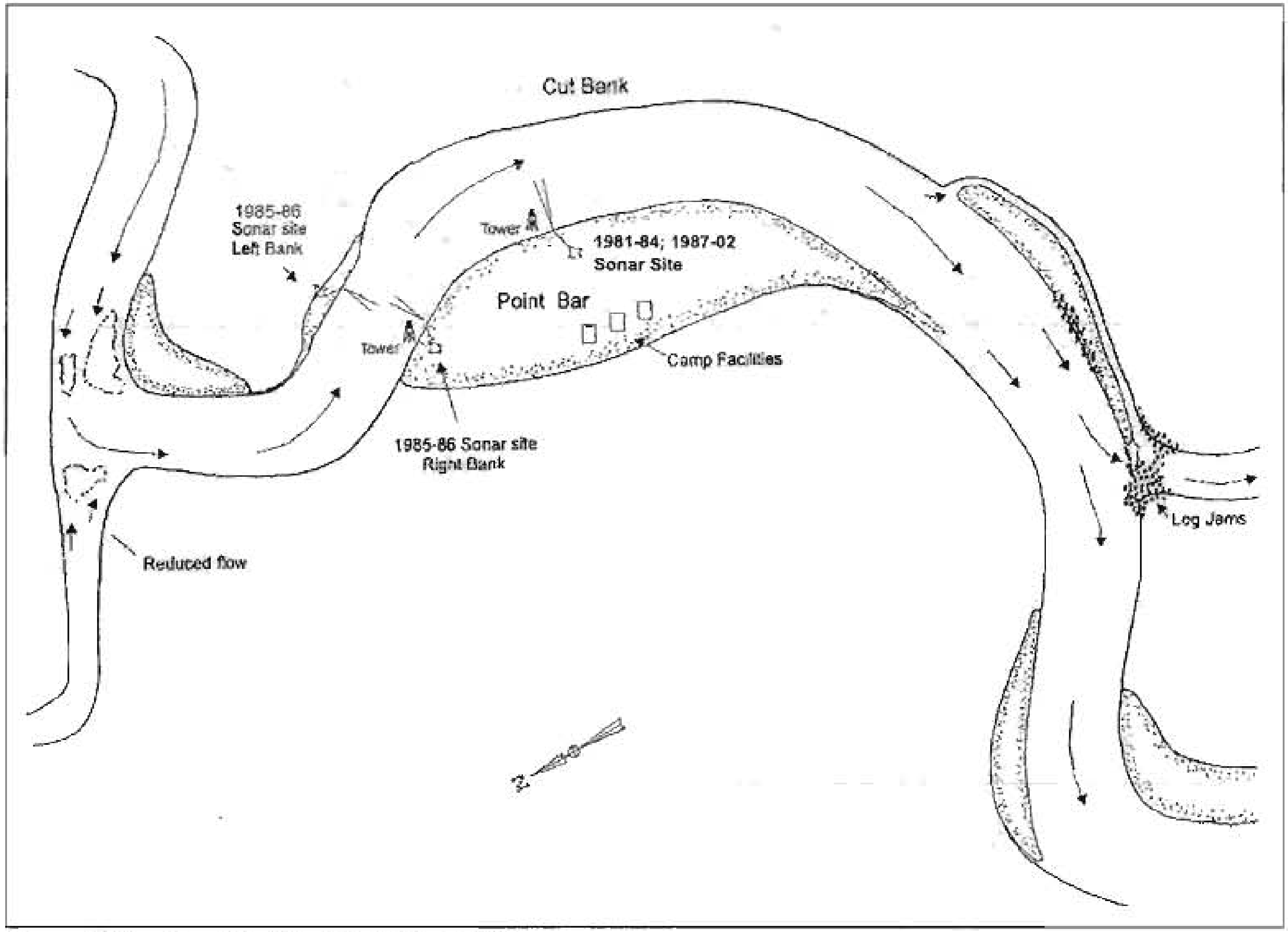

Figure 3. The Sheenjek River sonar project site.

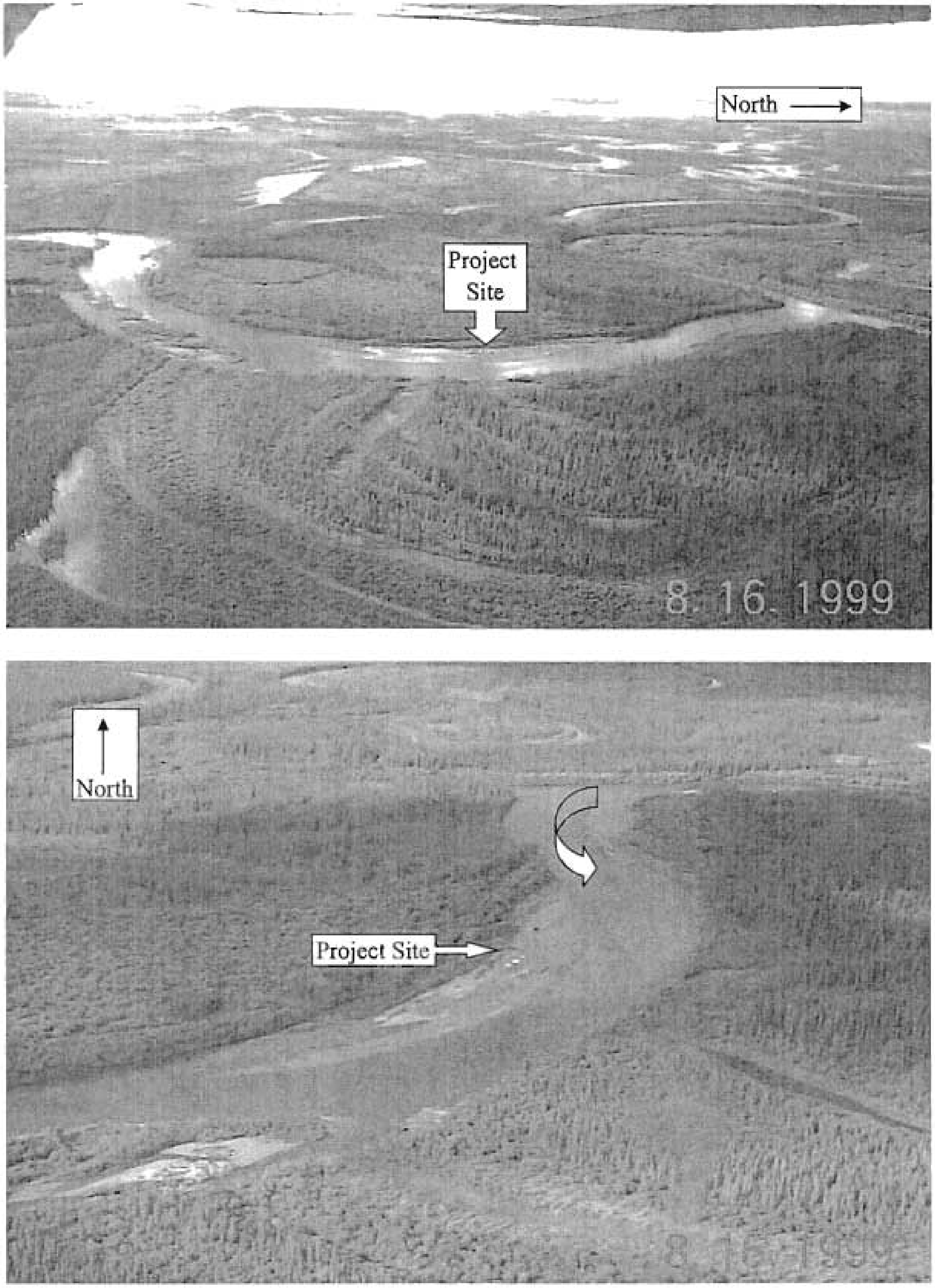

Figure 4. Aerial photographs of the Sheenjek River sonar project site, August 16, 1999.

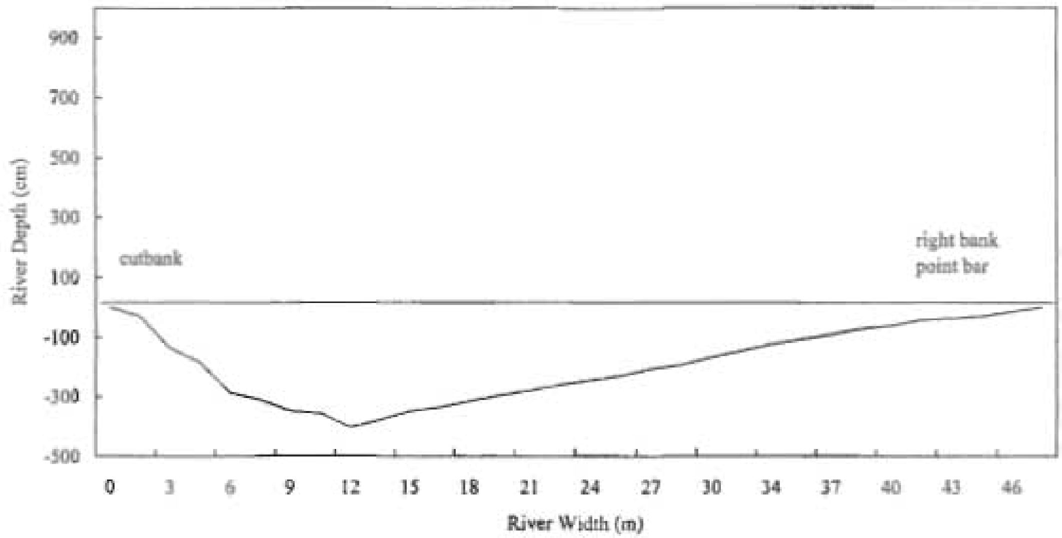

Figure 5. Depth profile (downstream view) made August 9, 2002 at the Sheenjek River sonar project site.

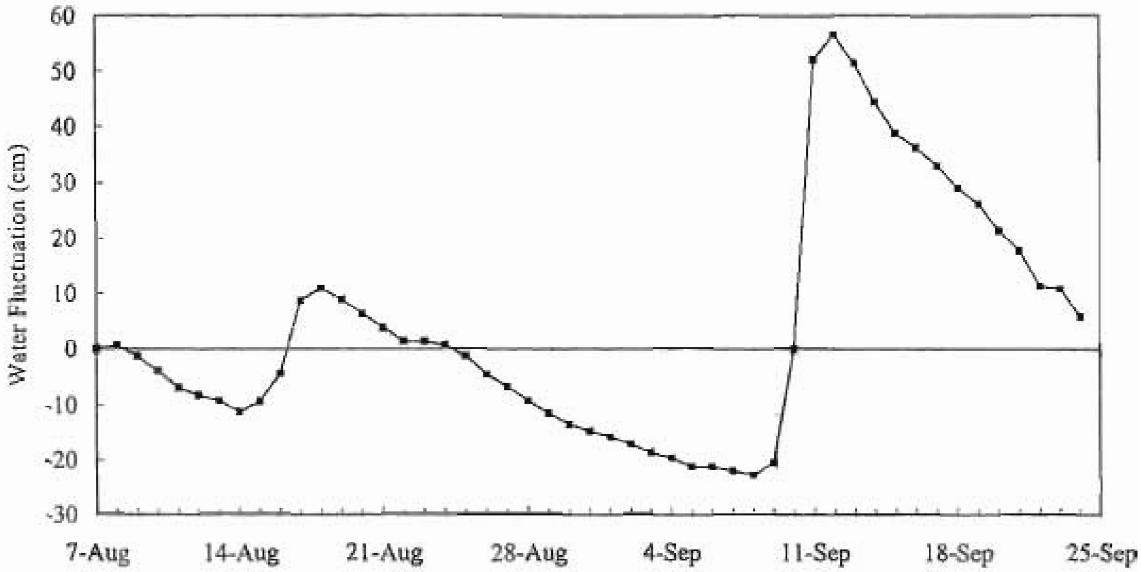

Figure 6. Changes in daily water elevation relative to August 7, Sheenjek River sonar project site, 2002.

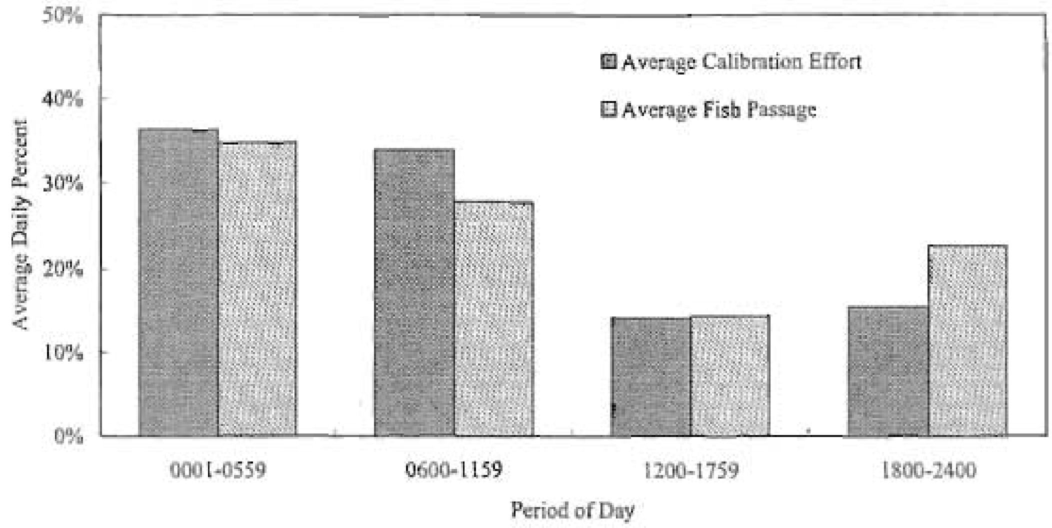

Figure 7. Average sonar calibration effort versus average fish passage in the Sheenjek River, 2002.

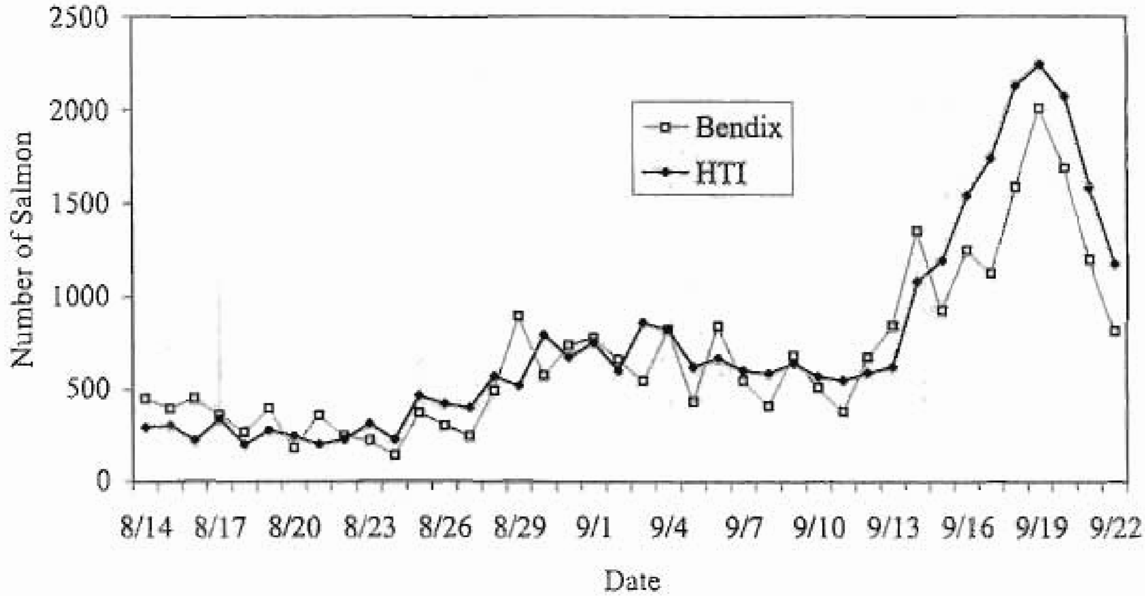

Figure 8. Bendix and HTI sonar-estimated passage of fall chum salmon in the Sheenjek River August 14 through September 14, 2002.

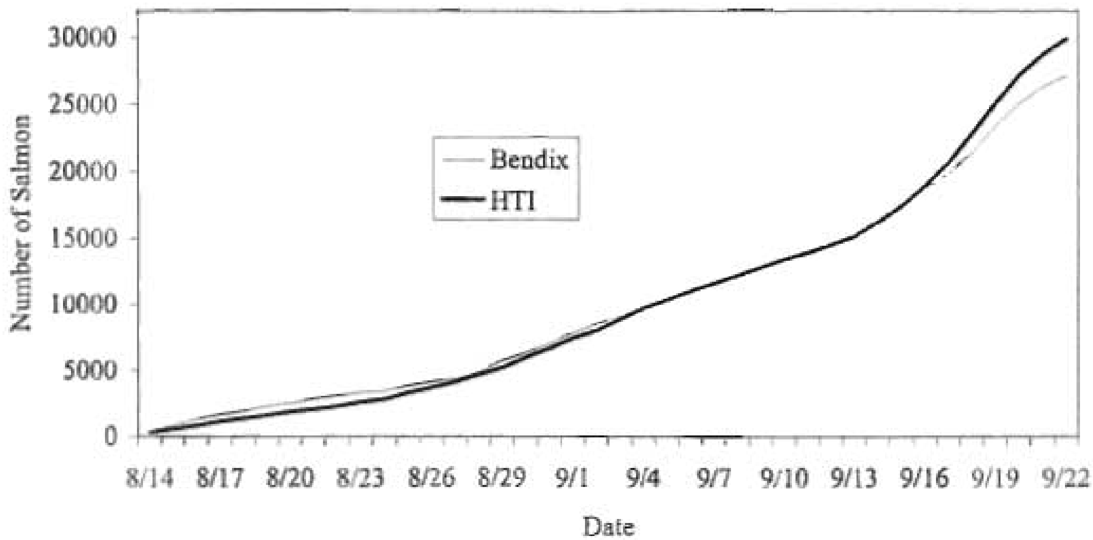

Figure 9. Bendix and HTI sonar, cumulative escapement estimate in the Sheenjek River, August 14 through September 22, 2002.

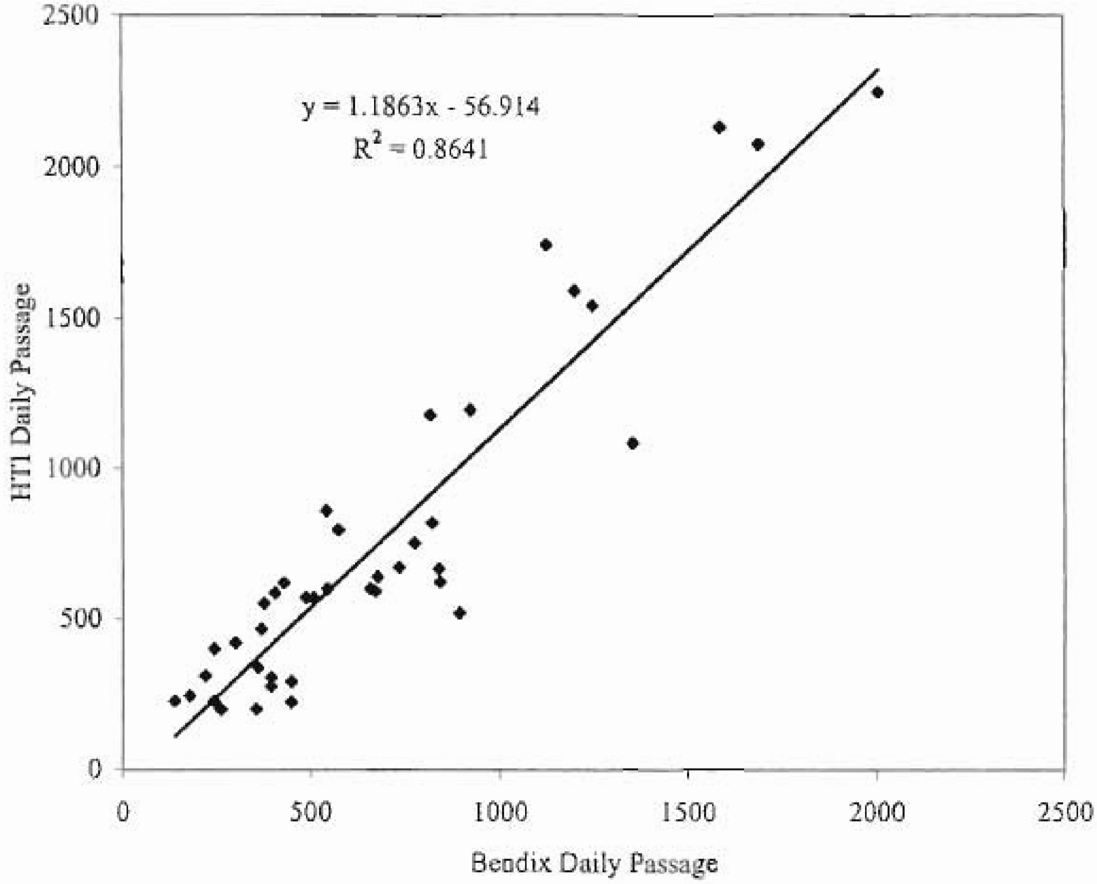

Figure 10. Bendix and HTI sonar, comparison of daily fall chum salmon passage in the Sheenjek river, August 14 through September 22, 2002.

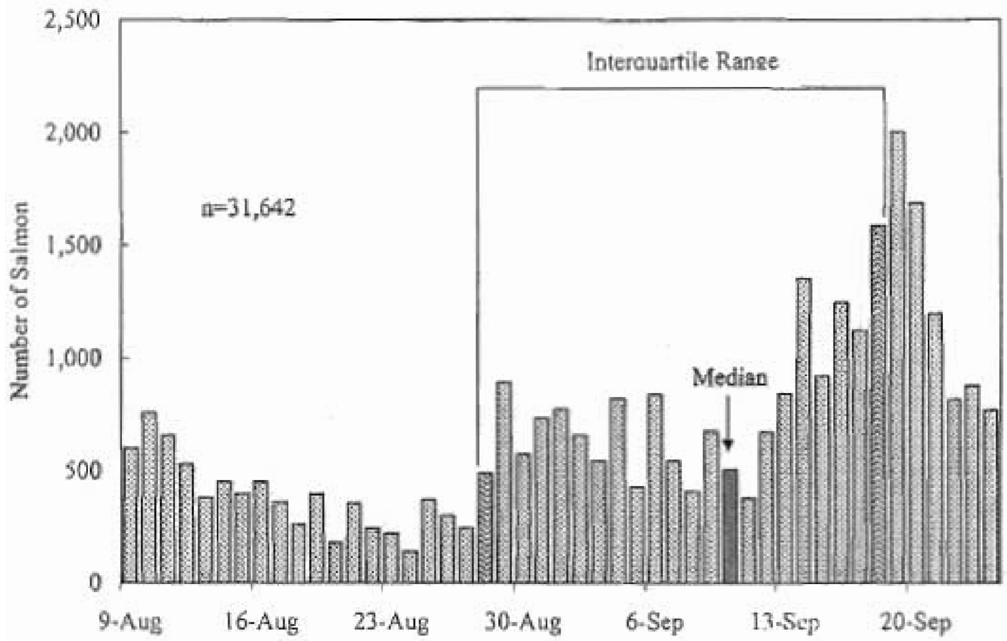

Figure 11. Adjusted fall chum salmon sonar counts by date, Sheenjek River, 2002.

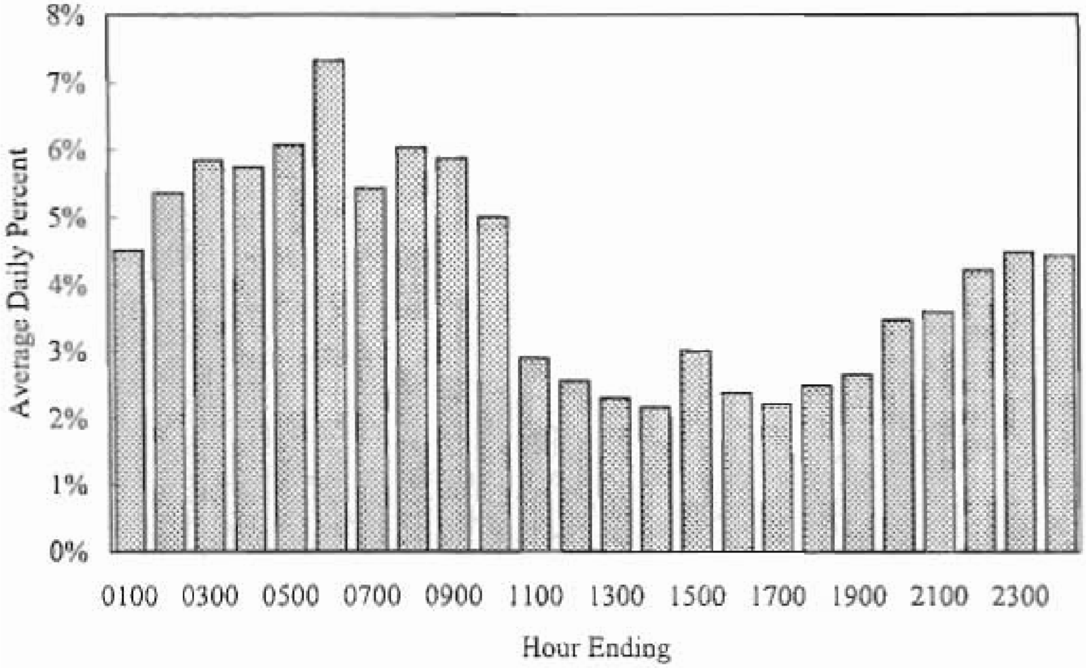

Figure 12. Diel migration pattern of fall chum salmon observed in the Sheenjek River, August 9 through September 24, 2002.

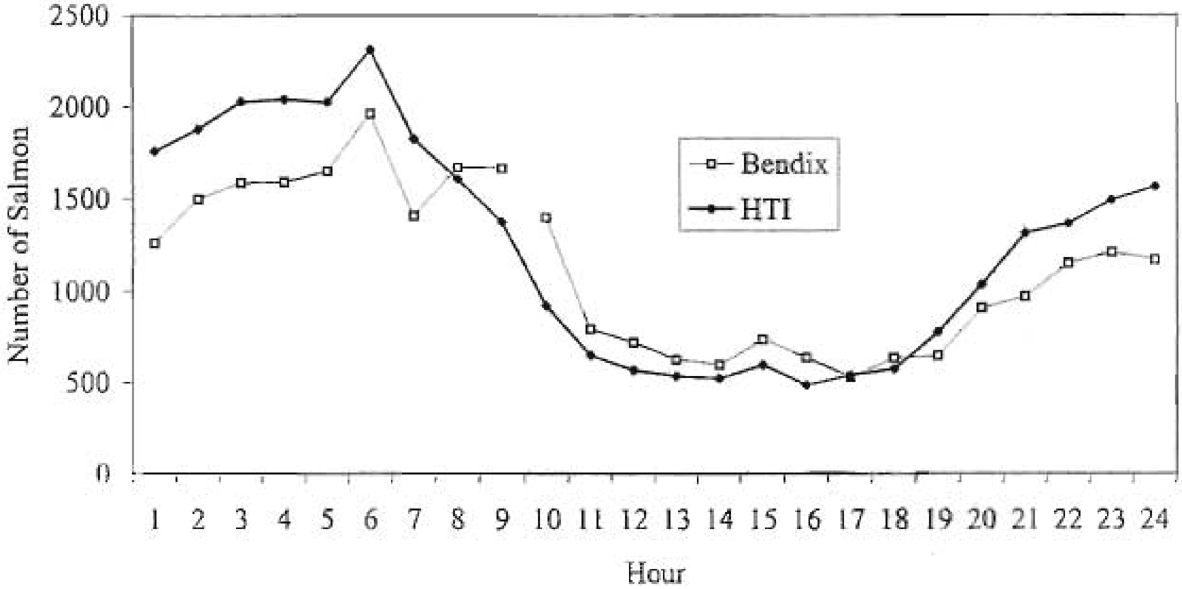

Figure 13. Bendix and HTI sonar, diel migration pattern of fall chum salmon observed in the Sheenjek River, August 14 through September 22, 2002.

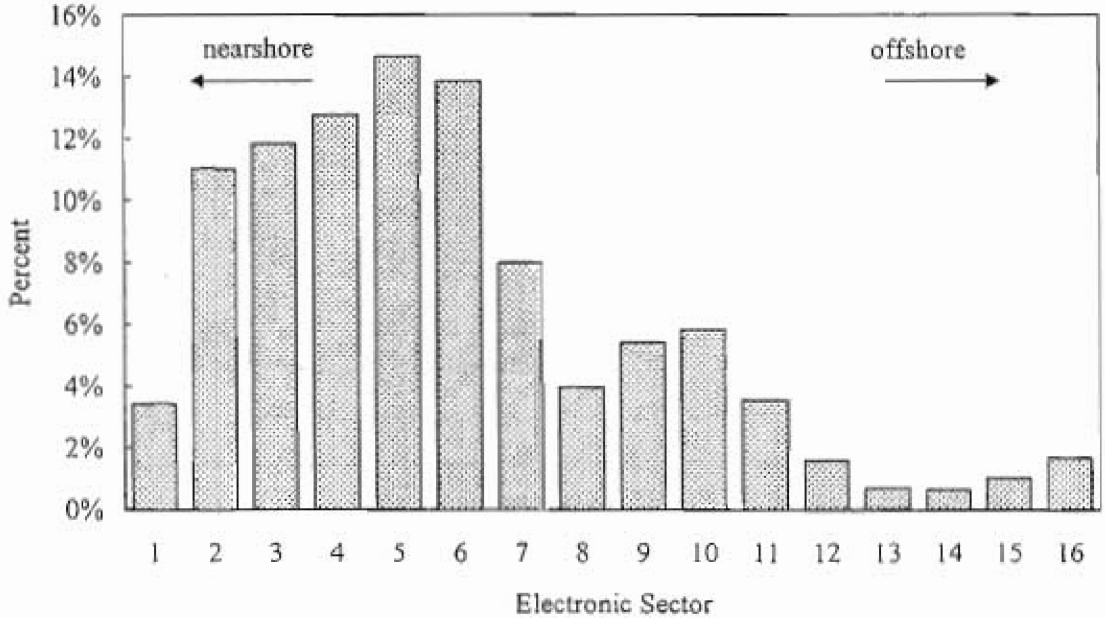

Figure 14. Average distribution of Bendix sonar counts by electronic sector attributed to fall chum salmon in the Sheenjek River, 2002.

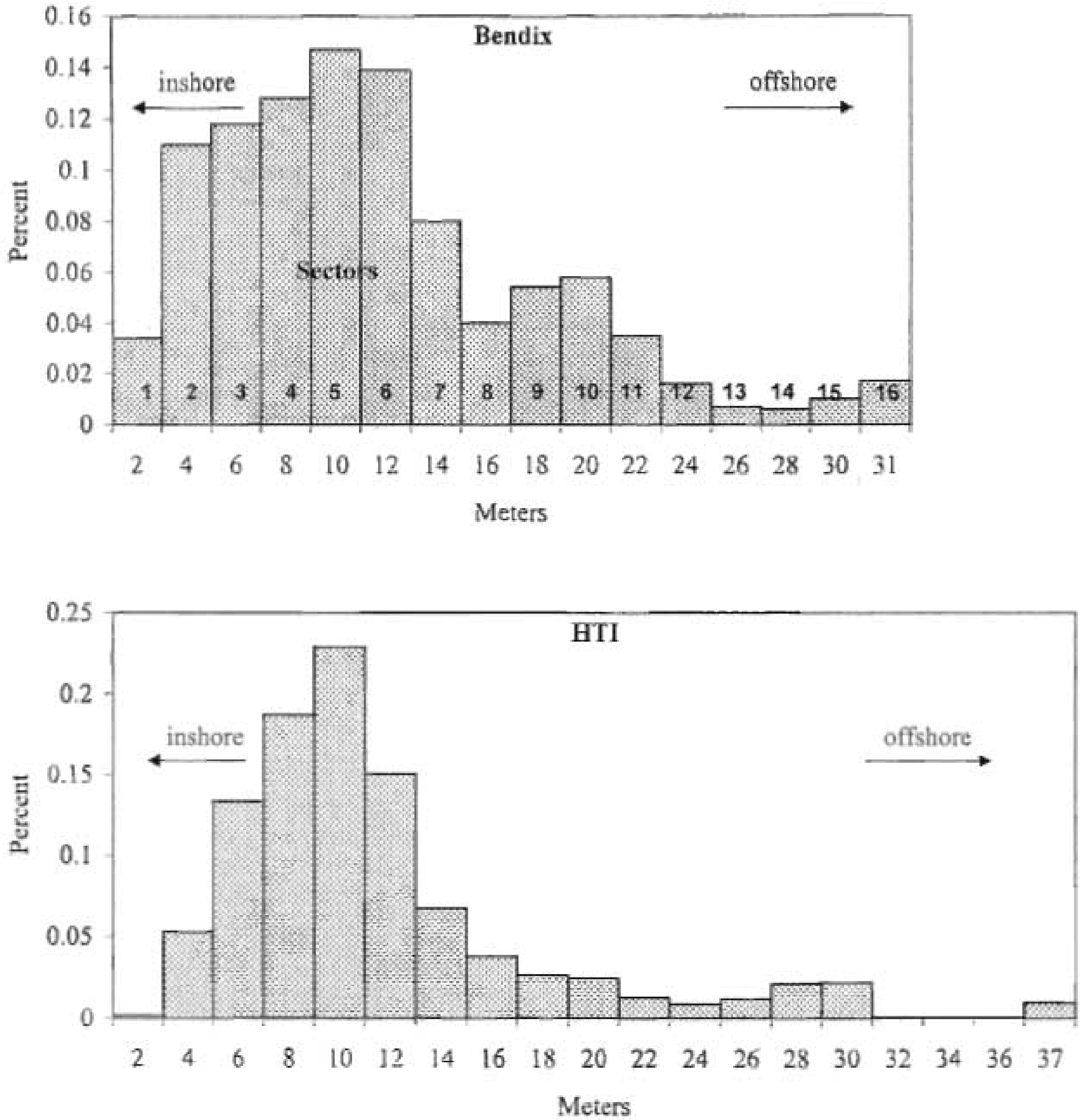

Figure 15. Bendix and HTI sonar, comparison of upstream fall chum salmon distribution in the Sheenjek River, 2002.

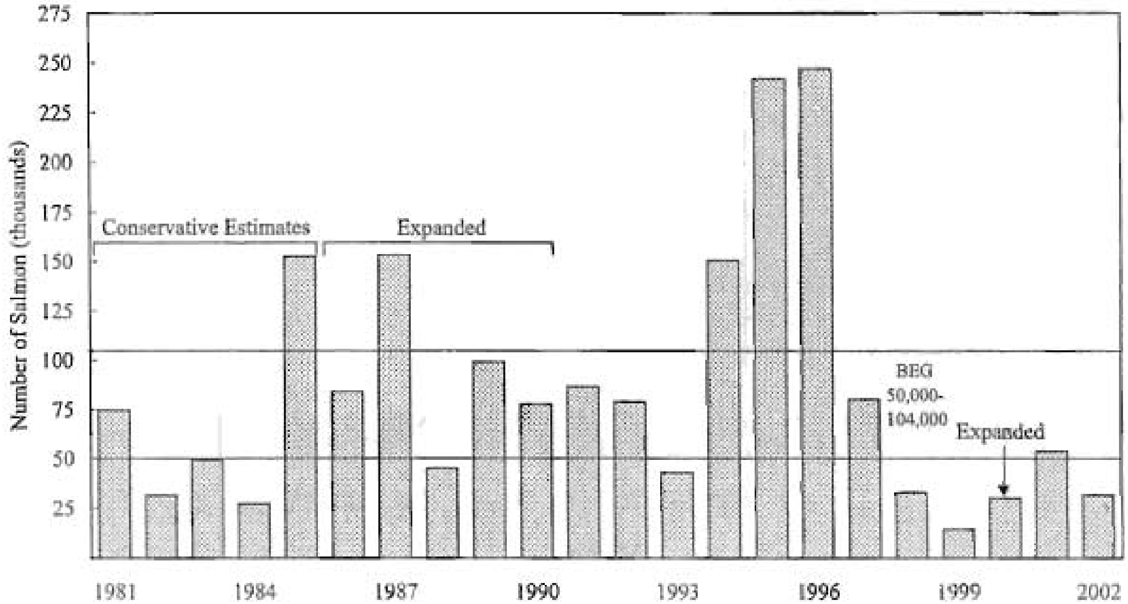

Figure 16. Sonar-estimated escapement of fall chum salmon in the Sheenjek River, 1981-2002.

APPENDIX

Appendix A. Technical specifications for the Model 241 Portable Split-Beam Digital Echo Sounder (taken from model 241 operators manual).

Size:	10 inches wide x 4.3 high x 17 long, without PC or transducer (254 mm wide x 109 high x 432 long).
Weight:	20 lb. (9 kg) without PC or transducer.
Power Supply:	Nominal 12 VDC standard (120 VAC and 240 VAC optional).
Operating Temperature:	5-50°C (41-122°F).
Power Consumption:	30 watts (120 - 200 kHz), without laptop PC.
Frequency:	200 kHz standard (120 kHz and 420 kHz optional).
Transmit Power:	100 watts standard for 120-200 kHz. 50 watts standard for 420 kHz
Dynamic Range:	140 dB
Transmitter:	Output power is adjustable in four steps over a 20 dBw range (+2, +8, +14, and 20 dBw).
Pulse Length:	Selectable from 0.1 msec to 1.0 msec in 0.1 msec steps.
Bandwidth:	Receiver bandwidth is automatically adjusted to optimize performance for the selected pulse length.
Receiver Gain:	Overall receiver gain is adjustable in five steps over a 40 dB range (-16, -8, 0, +8, +16 dB).
TVG Functions:	Simultaneous 20 and 40 log(R)+2αr TVG. Spreading loss and alpha are programmable to nearest 0.1 dB. Total TVG range is 80 dB. TVG start is selectable in 1m increments. The minimum TVG start is 1.0 m to maximum of 200 m.
Receiver Blanking:	Start and stop range blanking is selectable in 1m steps.
Undetected Output:	12 kHz, for each formed beam
Detected Output:	10 volts peak
System Synchronization:	Internal or external trigger
Ping Rate:	0.5-40.0 pings/sec
Phase Calculation:	Quadrature demodulation
Angular Resolution:	+/- <0.1° (6° beam width, 200 kHz)
Tape recording:	With Split-Beam Data Tape Interface and optional Digital Audio Tape (DAT) recorder, directly records the digitized split-beam data, permitting complete reconstruction of the raw data output.
Calibrator:	Local receiver calibration check using internal calibration source. Pulse and CW calibration functions provided in step settings.
Positioning:	GPS positioning information (NMEA 0183 format) via serial port of computer

Appendix B. *C* program code used to remove stationary object (bottom) echoes from HTI .raw echo files.

```
//------------------------------------------------
//BottRemov.c
//Carl Pfisterer 11/15/2000
//
//This program removes bottom from a *.raw file by calculating a moving
//average of TS in each range bin and removing echoes that are within
//a specified distance from this average.
//
//Note: This program isn't written in a real good way.  When I get the
//chance I will try to re-write the program using a more object
//oriented design.
//------------------------------------------------
#include <stdio.h>
#include <math.h>
#include <stdlib.h>
#include <string.h>

//Data Structures
typedef struct
{
	int fishNum;
	int pingNum;
	int include;
	char row[150];
	float TS;
	float range;
}SonarInfo;

const int avgNum=1000;

typedef struct
{
	float values[avgNum];		//TS values used in average
	int pingGaps[avgNum];		//Ping gaps
	float average;	//Average of TS values in range bin
	float gapSum;
	float sum;			//Sum of TS values in range bin
	int number;			//Number of values averaged over
	int lastPing;	//Ping number of last ping used in calculating the moving average
     float prevAvg;
     float sdDev;
}EchoRange;
```

```
typedef struct
{
        char headerRow[150];
}HeaderInfo;

//Prototypes
void ReadData(FILE *inFile,HeaderInfo *hRows,SonarInfo *sData,int numLines);
void PrintData(HeaderInfo *hRows,SonarInfo *sData,int numLines);
void WriteData(FILE *inFile,HeaderInfo *hRows,SonarInfo *sData,int numLines);
void WriteDebug(FILE *debugFile,SonarInfo *sData,int numLines);
void CalcStats(int numLines,SonarInfo *sData,EchoRange *rangeBins);
void ExtractData(int numLines,SonarInfo *sData);
void GetFishNum(int i,SonarInfo *sData);
void GetTS(int i,SonarInfo *sData);
void GetRange(int i,SonarInfo *sData);
void GetPingNum(int i,SonarInfo *sData);
int GetHeaderLength(FILE *inFile);
int GetNumLines(FILE *inFile);
float ExtractNumber(char dataStr[],int numSkip);
int GetMaxRng(int numLines,SonarInfo *sData);
void InitializeBins(EchoRange *rangeBins,int lastPing);

//Globals
int headerLength;
//int avgNum;
int numBins;
float binLength;
float critical;          //Critcal value used for filtering
float threshold=-40;
int minNum=70;                  //Percentage of pings that must have echoes
//-------------------------------------------------
//This long ugly mess is just what a main function
//should not be...long.  Well, this was just a quick
//and dirty implementation, if I ever have the time
//or desire I will implement this better.
//-------------------------------------------------
int main(void)
{
        FILE *inFile;
        //FILE *debugFile;
        char fileName[100],saveFile[100],tempCrit[10];
        HeaderInfo *hRows;
        SonarInfo *sData;
```

```
	EchoRange *rangeBins;
	int numLines,maxRange;

	printf("Enter the file name or return to exit: \n");
	while(strlen(gets(fileName))>0)
	{
		strcpy(saveFile,fileName);
		strcat(saveFile,"f.raw");
		strcat(fileName,".raw");		//Append .raw to the file name
		if (( inFile = fopen(fileName, "r")) == NULL)
		{
			printf("Can't open file %s.\n",fileName);
			exit(1);
		}
		//printf("Enter the number of pings to average over");
		//gets(tempCrit);
		//avgNum=atoi(tempCrit);
		printf("Enter the percentage of max missed pings: ");
		gets(tempCrit);
		minNum=atoi(tempCrit);
		//printf("Enter the critical value for filtering (in positive dB):");
		printf("Enter the window width (number of std dev): ");
		gets(tempCrit);
		critical=atof(tempCrit);
		printf("Enter the size of the range bins in meters: ");
		gets(tempCrit);
		binLength=atof(tempCrit);
		headerLength=GetHeaderLength(inFile);
		hRows=new HeaderInfo[headerLength];
		numLines=GetNumLines(inFile);
		sData=new SonarInfo[numLines];
		ReadData(inFile,hRows,sData,numLines);
		ExtractData(numLines,sData);
		maxRange=GetMaxRng(numLines,sData)+1;			//add two to give
some wiggle room
		numBins=int(maxRange/binLength)+1;
		rangeBins=new EchoRange[numBins];
		InitializeBins(rangeBins,0);
		CalcStats(numLines,sData,rangeBins);
		fclose(inFile);
		if (( inFile = fopen(saveFile, "w")) == NULL)
		{
			printf("Can't open file %s.\n",fileName);
```

```
                    exit(1);
                }
                //PrintData(hRows,sData,fData,numLines);
                WriteData(inFile,hRows,sData,numLines);
                printf("Done! \n");

                fclose(inFile);

                //fclose(debugFile);
                delete hRows;
                delete sData;
                printf("Enter the file name or return to exit: \n");
        }
}

//-----------------------------------------------
//This function gets the number of lines in the header
//-----------------------------------------------
int GetHeaderLength(FILE *inFile)
{
        fpos_t pos;
        char buffer[150],temp[8];
        int number=0,done=0,i;

        printf("getting header length\n");
        fgetpos(inFile,&pos);
        while(!done)
        {
                number++;
                fgets(buffer,150,inFile);
                for(i=0;i<7;i++)
                {
                        temp[i]=buffer[i];
                }
                temp[7]='\0';
                if(!strcmp(temp,"* Start"))
                        done=1;
        }
        fsetpos(inFile,&pos);
        return number;
}

//-----------------------------------------------
```

```
//This function gets the number of lines that exist for fish data.
//Two is subtraced from this number because there are a couple of
//rows at the end without fish data, there are end of file information.
//-------------------------------------------------
int GetNumLines(FILE *inFile)
{
	fpos_t pos;
	char buffer[150];
	int numLines=0;

	printf("getting the number of lines\n");
	fgetpos(inFile,&pos);
	while(fgets(buffer,150,inFile)!=NULL)
	{
		numLines++;
	}
	fsetpos(inFile,&pos);
	numLines=numLines-headerLength;

	return numLines;
}

//-------------------------------------------------
//This function reads in the rows and saves the entire row into
//a character array.  This is not very efficient but it makes it
//easier to export the data in the correct format.
//-------------------------------------------------
void ReadData(FILE *inFile,HeaderInfo *hRows,SonarInfo *sData,int numLines)
{
	int i;
	char buffer[150];

	//Read in the header rows
	printf("reading in data\n");
	for(i=0;i<headerLength;i++)
	{
		fgets(hRows[i].headerRow,150,inFile);
	}
	for(i=0;i<numLines;i++)
	{
		fgets(buffer,150,inFile);
		strcpy(sData[i].row,buffer);
	}
```

```
}

int GetMaxRng(int numLines,SonarInfo *sData)
{
        int i;
        float tempMax=0;

        for(i=0;i<numLines;i++)
        {
                if(sData[i].range>tempMax)
                        tempMax=sData[i].range;
        }

        return tempMax;
}

//-----------------------------------------------------
//Calculates the average voltages in each of the range bins
//-----------------------------------------------------
void CalcStats(int numLines,SonarInfo *sData,EchoRange *rangeBins)
{
        int i=0,j,k,l=0,arrayNum,arrayNum2,pingGap,numPings,lastPing;
      float prevSS,sd;
      int temp;

        printf("Computing moving averages and removing bottom\n");

        while(i<numLines-2)  //subtract two for the two rows of text ending the file
        {
                if(sData[i].row[0]=='*')        //If start of a new sequence reinitialize
                {
                        lastPing=(int)ExtractNumber(sData[i].row,14);
                        InitializeBins(rangeBins,0);
                        l=0;                    //l keeps track of how many echoes in the sequence,
i is for the entire file
                        i++;i++;                //go to the next line-have to do this twice for end
and start of sequences
                }
                arrayNum=int(sData[i].range/binLength);    //Calculate range bin
                pingGap=(sData[i].pingNum-rangeBins[arrayNum].lastPing)-1;
                rangeBins[arrayNum].sum=rangeBins[arrayNum].sum-
rangeBins[arrayNum].values[0]+sData[i].TS;
```

```
                rangeBins[arrayNum].gapSum=rangeBins[arrayNum].gapSum-
rangeBins[arrayNum].pingGaps[0]+pingGap;
                if(rangeBins[arrayNum].number<avgNum)
                        rangeBins[arrayNum].number++;

        rangeBins[arrayNum].average=rangeBins[arrayNum].sum/rangeBins[arrayNum].number
;
          rangeBins[arrayNum].prevAvg=rangeBins[arrayNum].average;
          if(rangeBins[arrayNum].number==1)
          {
            rangeBins[arrayNum].sdDev=0;
          }
          else if(rangeBins[arrayNum].number<avgNum)    //Moving average/sd hasn't kicked in
yet, not enough data.
          {
            if(rangeBins[arrayNum].number==2)
            {
              sd=(rangeBins[arrayNum].average-sData[i].TS); //for debugging
              rangeBins[arrayNum].sdDev=pow(pow((rangeBins[arrayNum].average-
sData[i].TS),2),.5);
            }
            else
            {
              prevSS=pow(rangeBins[arrayNum].sdDev,2)*(rangeBins[arrayNum].number-1);
              if(i)//(i>6000))
              {
                sd=rangeBins[arrayNum].sdDev;
                sd=rangeBins[arrayNum].number;
                sd=rangeBins[arrayNum].average;
              }
              rangeBins[arrayNum].sdDev=pow((prevSS+pow(rangeBins[arrayNum].average-
sData[i].TS,2))/(rangeBins[arrayNum].number-1),.5);
              if(i)//(i>6000))
              {
                sd=rangeBins[arrayNum].sdDev;
                sd=rangeBins[arrayNum].number;
                sd=rangeBins[arrayNum].average;
              }
            }
          }
          else //Start moving the std dev.
          {
            prevSS=pow(rangeBins[arrayNum].sdDev,2)*(rangeBins[arrayNum].number-1);
```

```
            sd=prevSS-pow(rangeBins[arrayNum].prevAvg-rangeBins[arrayNum].values[0],2)+
              pow(rangeBins[arrayNum].average-sData[i].TS,2);
            rangeBins[arrayNum].sdDev=pow(sd/(rangeBins[arrayNum].number-1),.5);
          }
          rangeBins[arrayNum].prevAvg=rangeBins[arrayNum].average;
              rangeBins[arrayNum].lastPing=sData[i].pingNum;
              //this next loop shifts the TS values in the bin down
              for(j=0;j<avgNum-1;j++)
              {
                      rangeBins[arrayNum].values[j]=rangeBins[arrayNum].values[j+1];
                      rangeBins[arrayNum].pingGaps[j]=rangeBins[arrayNum].pingGaps[j+1];
              }
              rangeBins[arrayNum].values[avgNum-1]=sData[i].TS;
              rangeBins[arrayNum].pingGaps[avgNum-1]=pingGap;
              numPings=rangeBins[arrayNum].gapSum+rangeBins[arrayNum].number;
          if(((sData[i].TS-
rangeBins[arrayNum].average)<(critical*rangeBins[arrayNum].sdDev))&&(rangeBins[arrayNu
m].gapSum/numPings*100<minNum)&&(l>avgNum))
            sData[i].include=0;
              else if(l==avgNum)
              {
                      for(k=i-l;k<i-1;k++)
                      {
                              arrayNum2=int(sData[k].range/binLength);

        numPings=rangeBins[arrayNum2].gapSum+rangeBins[arrayNum2].number;
                      if(((sData[k].TS-
rangeBins[arrayNum2].average)<(critical*rangeBins[arrayNum2].sdDev))&&(rangeBins[arrayN
um2].                                             gapSum/numPings*100<minNum))
                                      sData[k].include=0;
                      }
              }
              else
                      sData[i].include=1;
              i++;    //increment line number for file
              l++;    //increment line number for sequence
        }
}

void InitializeBins(EchoRange *rangeBins,int lastPing)
{
        int j,k;
```

```
        for(j=0;j<numBins;j++)
        {
                rangeBins[j].average=0;
                rangeBins[j].number=0;
                rangeBins[j].sum=0;
                rangeBins[j].lastPing=lastPing;
                rangeBins[j].gapSum=0;
           rangeBins[j].prevAvg=0;
           rangeBins[j].sdDev=0;
                for(k=0;k<avgNum;k++)
                {
                        rangeBins[j].values[k]=0;
                        rangeBins[j].pingGaps[k]=0;
                }
        }
}

//-------------------------------------------------
//Writes the filtered data back to the file, overwritting the previous
//data.  Note, the flag and fishNum==0 is used to put the sequence
//seperator data back in the file.
//-------------------------------------------------
void WriteData(FILE *inFile,HeaderInfo *hRows,SonarInfo *sData,int numLines)
{
        int i;

        printf("writing to file\n");
        for(i=0;i<headerLength;i++)
        {
                fprintf(inFile,"%s",hRows[i].headerRow);
        }

        for(i=0;i<numLines;i++)
        {
                if(sData[i].include||(sData[i].row[0]=='*'))
                {
                        fprintf(inFile,"%s",sData[i].row);
                }
        }
}

//-------------------------------------------------
```

```
//Used for debugging purposes to print a few rows of fish data and
//statistics on the screen.  Currently this function is commented
//out and is not called.
//-------------------------------------------------
void PrintData(HeaderInfo *hRows,SonarInfo *sData,int numLines)
{
        int i,j,numFish;
        int test1=5,test2=3;

        printf("print subset of data to screet\n");
        numFish=sData[numLines-1].fishNum;
        for(i=0;i<test1;i++)
        {
                printf("%s",hRows[i].headerRow);
        }
        for(i=0;i<numLines;i++)
        {
                for(j=0;j<test2;j++)
                {

        /*if((sData[i].fishNum==j+1)&&(fData[j].rangeSD>critical)&&(sData[i].fishNum))
                        {
                                printf("%s\n",sData[i].row);
                                printf("sd of range=%f\n",fData[j].rangeSD);
                        }*/
                }
        }
}

//-------------------------------------------------
//This function extracts the fish number and range for each
//line of data (each echo) from the information stored in
//the character array.
//-------------------------------------------------
void ExtractData(int numLines,SonarInfo *sData)
{
        int i;

        printf("extracting data\n");
        for(i=0;i<numLines;i++)
        {
                GetFishNum(i,sData);
                GetTS(i,sData);
```

```
                GetRange(i,sData);
                GetPingNum(i,sData);
        }
}

//-------------------------------------------------
//Extracts the fish number from the character array.
//-------------------------------------------------
void GetFishNum(int i,SonarInfo *sData)
{
        if(sData[i].row[0]!='*')        //Note, sequence rows start with a '*'
        {
                sData[i].fishNum=(int)ExtractNumber(sData[i].row,0);
        }
        else    //If it is a sequence row, assign fish number zero
                sData[i].fishNum=0;
}

//-------------------------------------------------
//GetTS extracts the range value from the character array.
//-------------------------------------------------
void GetTS(int i,SonarInfo *sData)
{
        if(sData[i].row[0]!='*')        //Note, sequence rows start with a '*'
        {
                //sData[i].TS=ExtractNumber(sData[i].row,10);           //Extracts TS value
                sData[i].TS=ExtractNumber(sData[i].row,2);                      //Extracts
voltage value
        }
        else    //If it is a sequence row, assign a TS of zero
                sData[i].TS=0;
}

void GetRange(int i,SonarInfo *sData)
{
        if(sData[i].row[0]!='*')
        {
                sData[i].range=ExtractNumber(sData[i].row,1);
        }
        else
                sData[i].range=0;
}
```

```
void GetPingNum(int i,SonarInfo *sData)
{
        if(sData[i].row[0]!='*')
        {
                sData[i].pingNum=ExtractNumber(sData[i].row,0);
        }
        else
                sData[i].pingNum=sData[i-1].pingNum;
}

//------------------------------------------------
//Again, another debugging tool.  This just writes a debug file
//that includes the data row and the statistics for each fish.
//The debug file is overwritten each time the program is run.
//This could probably be disabled but it doesn't take much room.
//------------------------------------------------
void WriteDebug(FILE *debugFile,SonarInfo *sData,int numLines)
{
        int i,j,numFish;

        printf("writing to debug file\n");
        numFish=sData[numLines-1].fishNum;
        for(i=0;i<numLines+1;i++)
        {
                for(j=0;j<numFish;j++)
                {
                        /*if(sData[i].fishNum==j+1)
                        {
                                fprintf(debugFile,"%s",sData[i].row);
                                fprintf(debugFile,"range=%4.2f  sd of Range=%6.4f delta=%6.4f
max delta=%6.4f\n",

        sData[i].range,fData[j].rangeSD,fData[j].rangeMaxDelta,fData[j].rangeFL);
                        }*/
                }
        }
}

//================================================
//Function extracts a number from a string that contains many groups
//of numbers or characters seperated by spaces.  Receives a string and
//the number of groups of characters or numbers to skip and returns
```

```
//the number of type float.
//==========================================
float ExtractNumber(char dataStr[],int numSkip)
{
	char numStr[10];
	int done=0,flag=0;
	int cntr=1,cntr2;

	while(!done)
	{
		cntr2=0;
		if(dataStr[cntr]!=' ')
		{
			while(dataStr[cntr+cntr2]!=' ')
			{
				if(flag==numSkip)	//how many groups of numbers to skip
				{
					numStr[cntr2]=dataStr[cntr+cntr2];
					numStr[cntr2+1]='\0';
					done=1;
				}
				cntr2++;
			}
			flag++;
		}
		if(cntr2)
			cntr=cntr+cntr2;
		else
			cntr++;
	}
	return atof(numStr);
}
```

Appendix C. Climatological and hydrologic observations at the Sheenjek River project site, 2002.

Date	Observation Time	Precipitation (code) [a]	Cloud Cover (code) [b]	Wind Direction and velocity (mph)	Temperature (C°) Water Surface	Temperature (C°) Air Minimum	Temperature (C°) Air Maximum	Water Level (cm) ± 24 h Change	Water Level (cm) relative to zero datum	Water Color (code) [c]	Remarks
07-Aug	1900	B	B	Calm				zero datum		A	Beautiful warm sunny weather. No thermometer until plane arrives.
08-Aug	1900	A	B	N 3				0.6	0.6	A	Install Bendix sonar and fish weir.
09-Aug	1900	B	O	Calm				-1.9	-1.3	A	Completed river profile. First full day of counts.
10-Aug	1900	B	S	SE 2				-2.5	-3.8	A	Supplies finally arrive.
11-Aug	1900	A	B	S 3		14	21	-3.2	-7.0	A	
12-Aug	1900	B	O	SW 4	12	8	31	-1.4	-8.6	A	Light evening rain.
13-Aug	1900	B	B	SW 6	11	6	21	-1.0	-9.6	A	Install HTI sonar. Frequent rain showers.
14-Aug	1900	A	S	SW 4	11	2	29	-2.0	-11.4	A	
15-Aug	1900	A	O	SW 12	10	7	28	1.9	-9.5	A	Continuous rain.
16-Aug	1900	A	O	SW 10	10	9	23	5.1	-4.4	A	Less rain today.
17-Aug	1900	A	B	SW 4	10	9	25	13.1	8.6	A	Windy afternoon.
18-Aug	1900	C	O	SW 4	10	2	17	2.3	10.9	A	Sunny morning, cloudy afternoon.
19-Aug	1900	A	O	Calm	10	8	15	-2.0	8.9	A	Intermittent rain.
20-Aug	1900	A	F	N 4	10	—	—	-2.5	6.4	A	Weather station battery dead.
21-Aug	1900	A	B	N 10	9	3	13	-2.5	3.8	A	Windy afternoon.
22-Aug	1900	A	S	N 6	9	1	15	-2.3	1.5	A	Windy morning.
23-Aug	1900	A	C	SW 2	9	1	18	0.0	1.5	A	Nice day.
24-Aug	1900	A	C	Calm	10	-1	18	-0.8	0.8	A	
25-Aug	1900	A	C	SW 2	10	-1	21	-2.0	-1.3	A	
26-Aug	2100	A	S	SW 3	10	1	22	-3.3	-4.6	A	
27-Aug	1900	A	S	Calm	11	2	24	-2.3	-6.9	A	
28-Aug	1900	A	B	SW 7	11	5	24	-2.5	-9.4	A	Partly cloudy.
29-Aug	1900	A	S	S 8	11	6	16	-2.3	-11.7	A	
30-Aug	1900	A	C	Calm	11	-5	20	-2.0	-13.7	A	
31-Aug	1900	A	C	S 3	11	4	20	-1.3	-15.0	A	
01-Sep	1900	B	C	N 4	10	2	14	-1.0	-16.0	A	Morning rain.
02-Sep	1900	A	B	SW 6	10	6	18	-1.3	-17.3	A	Evening clouds.
03-Sep	1900	A	B	S 2	10	8	19	-1.2	-18.8	A	Cloudy day.
04-Sep	1900	A	O	S 2	10	8	17	-1.0	-19.8	A	Humid.
05-Sep	1900	A	O	N 2	11	10	24	-1.5	-21.3	A	Drizzle all day
06-Sep	1900	B	O	S 4	11	10	18	0.0	-21.3	A	
07-Sep	1900	A	B	S 4	11	7	18	-0.8	-22.1	A	
08-Sep	1900	A	B	S 4	11	5	19	-0.8	-22.9	A	
09-Sep	1900	A	B	SW 5	10	4	15	2.3	-20.6	A	The water is rising.
10-Sep	1900	A	S	SW 6	8	9	15	20.6	0.0	A	Sheenjek river starting to look like a river (rising water).
11-Sep	1900	A	S	S 2	7	-1	14	52.1	52.1	C	High water, almost to sonar tent. Reset water gauge.
12-Sep	1900	B	B	SE 2	7	-3	10	4.5	56.6	B	Water level stabilizing.
13-Sep	1900	A	S	S 2	7	-1	22	-5.1	51.4	B	
14-Sep	1900	A	C	Calm	7	—	—	-7.1	44.3	A	Weather station battery dead again.
15-Sep	1900	A	C	Calm	8	—	—	-5.4	38.9	A	Sunny day.
16-Sep	1900	A	C	Calm	8	4	20	-2.5	36.3	A	
17-Sep	1900	A	C	NE 2	7	-1	20	-3.3	33.0	A	
18-Sep	1900	A	C	NE 10	7	—	—	-4.1	29.0	A	Windy day.
19-Sep	1900	B	B	NW 3	7	2	10	-2.8	26.2	A	
20-Sep	1900	A	O	—	7	2	11	-4.8	21.3	A	
21-Sep	1900	A	S	SW 2	7	1	12	-3.6	17.8	A	
22-Sep	1900	A	C	NW 4	6	-3	12	-6.4	11.4	A	HTI sonar off.
23-Sep	1900	A	C	N 3	5	1	12	-0.3	10.8		
24-Sep	1900	A	O	N 3	5	-5	11	-5.1	5.8		Break camp. Bendix sonar off at 2400.
Average					9	3	19				

[a] Precipitation code for the preceding 24-hr period. A = None; B = Intermittent rain; C = Continuous rain; D = snow and rain mixed; E = light snowfall; F = Continuous snowfall; G = Thunderstorm w/ or w/o precipitation.

[b] Instantaneous cloudcover code: C = Clear and visibility unlimited (CAVU); S = Scattered (<60%); B = Broken (60-90%); O = Overcast (100%); F = Fog or thick haze or smoke.

[c] Instantaneous water color code. A = Clear; B = Slightly murky or glacial; C = Moderately murky or glacial; D = Heavily murky or glacial; E = Brown, tannic acid stain.

Appendix D. Temporal distribution of daily sonar counts attributed to fall chum salmon in Sheenjek River, 2002.

Hour	09-Aug	10-Aug	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug
0100	37	18	17	20	9	15	15	21	27	6	16	2	3	27	8	4	16
0200	9	35	13	21	5	40	23	34	39	15	19	6	21	15	10	17	30
0300	29	36	13	17	8	25	20	21	9	8	24	5	10	13	16	20	22
0400	18	39	7	42	20	9	34	22	27	8	25	7	12	20	8	12	6
0500	45	41	14	31	21	14	73	11	19	9	26	6	17	7	8	8	11
0600	28	52	55	66	37	11	52	34	49	12	28	20	8	10	41	25	41
0700	46	28	53	63	18	4	31	30	15	22	33	12	34	3	23	3	18
0800	12	72	64	21	5	11	29	23	10	16	34	1	18	19	11	2	41
0900	32	5	45	17	3	23	6	15	2	1	31	0	129	0	3	9	3
1000	43	47	36	19	6	27	9	14	13	1	0	17	7	0	17	5	6
1100	47	5	16	22	3	0	4	3	21	3	4	16	1	1	8	0	6
1200	24	18	17	17	5	15	6	5	33	1	1	22	0	2	0	5	51
1300	12	44	13	28	1	35	10	14	14	17	2	10	8	0	4	2	3
1400	13	17	34	34	6	27	8	3	16	6	2	3	1	13	1	1	24
1500	55	54	64	16	5	18	8	6	15	16	14	6	6	23	7	1	8
1600	7	5	33	27	21	71	22	17	3	13	13	1	4	10	5	1	43
1700	10	14	25	12	96	5	1	8	1	5	4	1	10	11	11	0	4
1800	20	49	12	14	34	43	3	8	0	2	4	2	19	2	2	2	1
1900	26	56	25	6	8	5	6	13	7	17	13	5	8	5	12	3	1
2000	17	37	33	10	3	12	6	50	7	1	11	12	0	4	10	1	2
2100	17	16	23	17	7	2	5	30	2	15	12	13	9	12	3	3	4
2200	17	10	13	14	23	12	4	27	16	18	15	6	5	0	4	7	19
2300	27	3	16	5	16	12	13	23	10	29	40	2	18	39	4	3	8
2400	11	55	15	9	21	14	8	17	5	21	24	3	7	8	2	5	2
	602	756	656	528	381	450	396	449	360	262	395	179	355	243	220	139	370
	1.9%	2.4%	2.1%	1.7%	1.2%	1.4%	1.3%	1.4%	1.1%	0.8%	1.2%	0.6%	1.1%	0.8%	0.7%	0.4%	1.2%

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Hour	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	31-Aug	01-Sep	02-Sep	03-Sep	04-Sep	05-Sep	06-Sep	07-Sep	08-Sep	09-Sep	10-Sep
0100	23	9	18	1	23	53	8	15	12	31	27	47	11	46	32	25
0200	13	8	61	9	20	30	35	17	31	45	9	56	29	27	17	36
0300	24	12	44	17	33	37	32	20	32	27	26	67	36	49	13	33
0400	3	7	22	24	34	39	48	16	38	26	25	39	24	15	29	36
0500	16	13	80	30	21	36	48	11	21	35	16	20	24	66	36	14
0600	14	24	49	46	66	65	48	40	86	32	21	48	22	56	30	22
0700	24	16	16	46	19	27	45	41	44	35	16	30	68	9	27	40
0800	30	8	24	102	11	44	93	74	27	49	19	46	75	6	49	16
0900	15	6	2	150	5	44	161	100	34	31	33	40	22	5	36	15
1000	14	3	2	153	3	73	51	77	13	116	23	94	13	8	19	21
1100	9	0	5	54	3	60	49	42	3	33	13	21	3	8	25	31
1200	5	6	8	66	37	19	28	12	28	12	9	6	4	7	14	15
1300	2	13	2	11	29	57	5	2	9	36	9	42	11	2	47	13
1400	2	7	2	28	24	22	15	6	8	51	4	6	1	1	34	7
1500	0	4	3	35	36	21	24	4	12	35	16	72	37	4	21	11
1600	2	7	3	3	18	15	1	16	1	11	2	2	25	4	28	5
1700	6	11	7	15	23	0	0	2	3	35	14	45	6	16	27	5
1800	14	12	16	9	31	20	0	17	11	18	2	38	17	2	28	2
1900	12	1	21	20	21	3	0	2	5	12	9	36	6	8	35	3
2000	26	8	10	46	8	9	2	32	53	11	19	11	20	2	24	7
2100	14	8	7	7	6	19	25	18	35	19	16	13	12	3	22	24
2200	10	14	53	16	62	11	25	18	13	18	25	17	28	26	34	26
2300	14	19	14	3	28	24	14	6	17	14	35	7	31	20	22	44
2400	8	28	19	9	12	5	13	69	6	68	41	37	22	16	27	56
	300	244	488	892	573	733	774	657	542	820	429	838	543	406	676	507
	0.9%	0.8%	1.5%	2.8%	1.8%	2.3%	2.4%	2.1%	1.7%	2.6%	1.4%	2.6%	1.7%	1.3%	2.1%	1.6%

- continued -

Appendix D. (p 3 of 3)

	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep	21-Sep	22-Sep	23-Sep	24-Sep	Total	Percent
0100	41	18	58	51	40	101	85	62	106	73	44	41	36	25	1,424	0.045
0200	28	25	52	74	45	89	68	115	87	63	63	82	79	30	1,693	0.054
0300	20	28	37	92	71	70	72	185	85	93	90	55	113	41	1,847	0.058
0400	26	26	49	102	69	86	76	175	156	65	79	70	45	49	1,814	0.057
0500	34	37	27	103	100	65	130	124	108	86	79	64	95	19	1,919	0.061
0600	14	46	116	138	50	70	114	112	81	94	78	52	71	48	2,314	0.073
0700	19	41	48	64	79	69	32	58	97	52	49	50	36	60	1,715	0.054
0800	28	34	35	63	42	70	21	88	133	82	147	44	25	34	1,907	0.060
0900	17	23	31	37	33	85	39	76	119	119	94	74	58	26	1,854	0.059
1000	8	27	19	51	14	96	15	49	115	74	86	47	20	9	1,580	0.050
1100	8	15	17	39	5	38	9	10	35	121	56	13	12	17	916	0.029
1200	93% [a]	26	13	30	7	35	2	30	7	117	23	4	5	12	809	0.026
1300	26	39	10	40	3	5	4	12	21	51	19	5	7	4	727	0.023
1400		39	34	11	3	12	4	23	70	61	11	7	3	6	683	0.022
1500	3	28	27	9	5	12	4	34	71	61	17	5	15	4	952	0.030
1600	4	24	16	34	9	16	6	7	67	76	31	7	16	4	752	0.024
1700	7	19	11	7	4	11	8	27	61	44	30	25	6	5	698	0.022
1800	1	16	13	22	14	8	13	54	68	76	20	5	20	4	788	0.025
1900	5	28	16	5	5	26	30	66	86	68	19	5	14	57	840	0.027
2000	16	11	11	41	33	29	54	77	104	68	32	30	23	62	1,095	0.035
2100	16	19	29	86	105	64	61	42	92	44	37	22	39	43	1,135	0.036
2200	18	44	46	94	80	47	86	47	90	31	16	26	34	71	1,336	0.042
2300	19	27	54	101	45	71	108	72	77	31	43	51	58	80	1,417	0.045
2400	18	30	72	60	62	72	83	43	70	38	38	32	49	67	1,401	0.044
															31,616 [b]	
	376	670	841	1353	923	1247	1124	1588	2006	1688	1199	816	879	769	31,642 [c]	
	1.2%	2.1%	2.7%	4.3%	2.9%	3.9%	3.6%	5.0%	6.3%	5.3%	3.8%	2.6%	2.8%	2.4%		100%

[a] Indicates time when passage was estimated by interpolation, based upon average hourly distribution for days when sonar operated 24 hours.

[b] Totals include only days with 24 hours counts.

[c] Total estimated passage, including days with expanded counts.

Appendix E. Field calibrations for 1985-model Bendix sonar salmon counter, Sheenjek River 2002.

Date	Time Start	Duration (min.)	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
09-Aug	0	60	18	14	1.286	0.555	1.0	90	91.0	18
	805	15	9	13	0.692	0.555	1.0	90	91.0	36
	1201	15	5	4	1.250	0.555	1.0	90	91.0	20
	1807	15	8	10	0.800	0.555	1.0	90	91.0	32
10-Aug	2	15	5	6	0.833	0.555	1.0	90	91.0	20
	315	30	14	17	0.824	0.555	1.0	90	91.0	28
	605	15	3	6	0.500	0.555	1.0	90	91.0	12
	1115	15	3	3	1.000	0.555	1.0	90	91.0	12
	1600	15	3	1	3.000	0.555	1.0	90	91.0	12
	2100	15	4	2	2.000	0.555	1.0	90	91.0	16
11-Aug	0	15	3	5	0.600	0.555	1.0	90	91.0	12
	300	15	0	0	----	0.555	1.0	90	91.0	0
	600	30	15	27	0.556	0.555	1.0	90	91.0	30
	630	30	29	31	0.935	0.700	1.0	90	91.0	58
	1100	15	6	7	0.857	0.700	1.0	90	91.0	24
	1600	30	26	21	1.238	0.700	1.0	90	91.0	52
	2100	15	8	10	0.800	0.700	1.0	90	91.0	32
12-Aug	2	15	15	21	0.714	0.700	1.0	90	91.0	60
	315	15	4	8	0.500	0.700	1.0	90	91.0	16
	330	30	28	26	1.077	0.750	1.0	90	91.0	56
	600	15	4	4	1.000	0.750	1.0	90	91.0	16
	1100	15	2	2	1.000	0.750	1.0	90	91.0	8
	1600	15	1	1	1.000	0.750	1.0	90	91.0	4
	2101	15	5	6	0.833	0.750	1.0	90	91.0	20
13-Aug	0	15	5	16	0.313	0.750	1.0	90	91.0	20
	300	15	4	4	1.000	0.750	1.0	90	91.0	16
	600	15	8	13	0.615	0.750	1.0	90	91.0	32
	1100	15	0	0	----	0.750	1.0	90	91.0	0
	1600	30	32	64	0.500	0.750	1.0	90	91.0	64
	1645	15	8	5	1.600	0.800	1.0	90	91.0	32
	2100	15	5	5	1.000	0.800	1.0	90	91.0	20
14-Aug	0	15	3	1	3.000	0.800	1.0	90	91.0	12
	310	15	1	2	0.500	0.800	1.0	90	91.0	4
	600	20	4	5	0.800	0.800	1.0	90	91.0	12
	1100	15	1	1	1.000	0.800	1.0	90	91.0	4
	1600	15	2	1	2.000	0.800	1.0	90	91.0	8
	2100	15	4	8	0.500	0.800	1.0	90	91.0	16

- continued -

Date	Time Start	Duration (min.)	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
15-Aug	0	15	1	1	1.000	0.800	1.0	90	91.0	4
	304	30	23	21	1.095	0.800	1.0	90	91.0	46
	600	30	21	26	0.808	0.800	1.0	90	91.0	42
	1100	15	1	1	1.000	0.800	1.0	90	91.0	4
	1600	15	3	1	3.000	0.800	1.0	90	91.0	12
	2100	15	1	6	0.167	0.800	1.0	90	91.0	4
16-Aug	0	15	1	1	1.000	0.800	1.0	90	91.0	4
	300	15	8	7	1.143	0.800	1.0	90	91.0	32
	600	15	8	6	1.333	0.800	1.0	90	91.0	32
	1100	15	1	0	----	0.800	1.0	90	91.0	4
	1600	15	1	1	1.000	0.800	1.0	90	91.0	4
	2100	15	4	1	4.000	0.800	1.0	90	91.0	16
17-Aug	0	30	15	17	0.882	0.800	1.0	90	91.0	30
	300	15	8	7	1.143	0.800	1.0	90	91.0	32
	605	15	1	4	0.250	0.800	1.0	90	91.0	4
	1100	15	7	11	0.636	0.800	1.0	90	91.0	28
	1600	15	0	0	----	0.800	1.0	90	91.0	0
	2100	15	9	21	0.429	0.800	1.0	90	91.0	36
18-Aug	0	15	1	2	0.500	0.800	1.0	90	91.0	4
	315	15	4	5	0.800	0.800	1.0	90	91.0	16
	330	30	3	3	1.000	0.900	1.0	90	91.0	6
	600	15	9	13	0.692	0.900	1.0	90	91.0	36
	1100	15	0	0	----	0.900	1.0	90	91.0	0
	1600	15	0	0	----	0.900	1.0	90	91.0	0
	2100	15	2	2	1.000	0.900	1.0	90	91.0	8
19-Aug	0	15	5	5	1.000	0.900	1.0	90	91.0	20
	304	15	4	4	1.000	0.900	1.0	90	91.0	16
	600	30	16	12	1.333	0.900	1.0	90	91.0	32
	1100	15	1	1	1.000	0.900	1.0	90	91.0	4
	1600	15	4	4	1.000	0.900	1.0	90	91.0	16
	2100	30	12	12	1.000	0.900	1.0	90	91.0	24
20-Aug	0	15	0	0	----	0.900	1.0	90	91.0	0
	315	15	0	0	----	0.900	1.0	90	91.0	0
	600	15	7	8	0.875	0.900	1.0	90	91.0	28
	1100	15	6	10	0.600	0.900	1.0	90	91.0	24
	1600	15	1	0	----	0.900	1.0	90	91.0	4
	2100	15	5	26	0.192	0.900	1.0	90	91.0	20

- continued -

Appendix E. (page 3 of 8).

Date	Time Start	Duration (min.)	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
21-Aug	0	15	0	0	----	0.900	1.0	90	91.0	0
	420	30	17	13	1.308	0.900	1.0	90	91.0	34
	450	10	5	6	0.833	0.950	1.0	90	91.0	30
	600	15	3	3	1.000	0.950	1.0	90	91.0	12
	1100	15	1	0	----	0.950	1.0	90	91.0	4
	1600	15	0	0	----	0.950	1.0	90	91.0	0
	2100	15	1	0	----	0.950	1.0	90	91.0	4
22-Aug	0	15	6	9	0.667	0.950	1.0	90	91.0	24
	303	15	8	9	0.889	0.950	1.0	90	91.0	32
	600	15	1	0	----	0.950	1.0	90	91.0	4
	1100	15	0	0	----	0.950	1.0	90	91.0	0
	1600	15	0	0	----	0.950	1.0	90	91.0	0
	2100	15	0	0	----	0.950	1.0	90	91.0	0
23-Aug	0	15	2	0	----	0.950	1.0	90	91.0	8
	315	15	3	3	1.000	0.950	1.0	90	91.0	12
	600	30	19	18	1.056	0.950	1.0	90	91.0	38
	1100	15	1	0	----	0.950	1.0	90	91.0	4
	1600	15	8	30	0.267	0.950	1.0	90	91.0	32
	2100	15	2	5	0.400	0.950	1.0	90	91.0	8
24-Aug	0	15	0	2	0.000	0.950	1.0	90	91.0	0
	310	15	3	2	1.500	0.950	1.0	90	91.0	12
	325	15	6	5	1.200	0.970	1.0	90	91.0	24
	600	15	0	0	----	0.970	1.0	90	91.0	0
	1100	30	9	17	0.529	0.970	1.0	90	91.0	18
	1600	15	0	0	----	0.970	1.0	90	91.0	0
	2100	15	1	3	0.333	0.970	1.0	90	91.0	4
25-Aug	0	15	1	1	1.000	0.970	1.0	90	91.0	4
	300	15	6	6	1.000	0.970	1.0	90	91.0	24
	605	15	6	7	0.857	0.970	1.0	90	91.0	24
	1100	15	4	0	----	0.970	1.0	90	91.0	16
	1600	15	4	2	2.000	0.970	1.0	90	91.0	16
	2100	30	17	38	0.447	0.970	1.0	90	91.0	34
26-Aug	0	15	3	1	3.000	0.970	1.0	90	91.0	12
	300	15	2	3	0.667	0.970	1.0	90	91.0	8
	600	30	19	28	0.679	0.970	1.0	90	91.0	38
	1102	15	3	12	0.250	0.970	1.0	90	91.0	12
	1600	15	1	0	----	0.970	1.0	90	91.0	4
	2100	15	3	1	3.000	0.970	1.0	90	91.0	12

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Date	Time Start	Duration (min.)	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
27-Aug	0	15	1	0	----	0.970	1.0	90	91.0	4
	15	15	3	2	1.500	0.990	1.0	90	91.0	12
	300	15	7	7	1.000	0.990	1.0	90	91.0	28
	600	15	7	17	0.412	0.990	1.0	90	91.0	28
	1100	15	0	0	----	0.990	1.0	90	91.0	0
	1600	15	4	7	0.571	0.990	1.0	90	91.0	16
	2100	15	3	3	1.000	0.990	1.0	90	91.0	12
28-Aug	0	15	6	4	1.500	0.990	1.0	90	91.0	24
	300	15	7	6	1.167	0.990	1.0	90	91.0	28
	600	15	2	1	2.000	0.990	1.0	90	91.0	8
	1100	15	7	47	0.149	0.990	1.0	90	91.0	28
	1600	15	0	0	----	0.990	1.0	90	91.0	0
	2100	30	32	30	1.067	0.990	1.0	90	91.0	64
29-Aug	0	15	1	0	----	0.990	1.0	90	91.0	4
	300	15	3	3	1.000	0.990	1.0	90	91.0	12
	600	30	29	25	1.160	0.990	1.0	90	91.0	58
	1100	15	0	0	----	0.990	1.0	90	91.0	0
	1600	15	0	0	----	0.990	1.0	90	91.0	0
	2100	15	1	1	1.000	0.990	1.0	90	91.0	4
30-Aug	0	15	9	10	0.900	0.990	1.0	90	91.0	36
	300	15	6	9	0.667	0.990	1.0	90	91.0	24
	600	15	9	7	1.286	0.990	1.0	90	91.0	36
	1203	30	78	292	0.267	0.990	1.0	90	91.0	156
	1600	30	17	34	0.500	0.990	1.0	90	91.0	34
	2100	15	3	6	0.500	0.990	1.0	90	91.0	12
31-Aug	0	30	30	27	1.111	0.990	1.0	90	91.0	60
	300	15	7	4	1.750	0.990	1.0	90	91.0	28
	600	30	18	19	0.947	0.990	1.0	90	91.0	36
	1100	15	0	0	----	0.990	1.0	90	91.0	0
	1600	15	0	0	----	0.990	1.0	90	91.0	0
	2100	15	9	7	1.286	0.990	1.0	90	91.0	36
01-Sep	30	15	2	4	0.500	0.990	1.0	90	91.0	8
	300	15	9	9	1.000	0.990	1.0	90	91.0	36
	600	15	4	3	1.333	0.990	1.0	90	91.0	16
	1100	15	8	6	1.333	0.990	1.0	90	91.0	32
	1600	15	0	0	----	0.990	1.0	90	91.0	0
	2100	15	8	9	0.889	0.990	1.0	90	91.0	32

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Date	Time Start	Duration (min.)	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Cmg Range	Total Range	Passage Rate (fish/hour)
02-Sep	15	15	3	3	1.000	0.990	1.0	90	91.0	12
	300	15	1	0	----	0.990	1.0	90	91.0	4
	600	15	9	8	1.125	0.990	1.0	90	91.0	36
	1100	15	0	0	----	0.990	1.0	90	91.0	0
	1604	15	0	0	----	0.990	1.0	90	91.0	0
	2100	15	6	7	0.857	0.990	1.0	90	91.0	24
03-Sep	0	15	8	6	1.333	0.990	1.0	90	91.0	32
	300	30	19	40	0.475	0.990	1.0	90	91.0	38
	600	30	32	41	0.780	0.990	1.0	90	91.0	64
	1109	30	17	45	0.378	0.990	1.0	90	91.0	34
	1607	15	1	0	----	0.990	1.0	90	91.0	4
	2100	15	9	10	0.900	0.990	1.0	90	91.0	36
04-Sep	0	30	20	17	1.176	0.990	1.0	90	91.0	40
	300	15	7	8	0.875	0.990	1.0	90	91.0	28
	600	30	38	42	0.905	0.990	1.0	90	91.0	76
	1100	15	5	3	1.667	0.990	1.0	90	91.0	20
	1600	15	1	1	1.000	0.990	1.0	90	91.0	4
	2130	15	6	5	1.200	0.990	1.0	90	91.0	24
05-Sep	17	30	21	20	1.050	0.990	1.0	90	91.0	42
	300	15	9	14	0.643	0.990	1.0	90	91.0	36
	600	30	13	35	0.371	0.990	1.0	90	91.0	26
	1100	15	3	4	0.750	0.990	1.0	90	91.0	12
	1600	15	0	0	----	0.990	1.0	90	91.0	0
	2100	15	6	3	2.000	0.990	1.0	90	91.0	24
06-Sep	0	15	5	4	1.250	0.990	1.0	90	91.0	20
	300	15	4	0	----	0.990	1.0	90	91.0	16
	600	30	14	11	1.273	0.990	1.0	90	91.0	28
	1100	15	0	0	----	0.990	1.0	90	91.0	0
	1600	15	1	1	1.000	0.990	1.0	90	91.0	4
	2100	15	4	3	1.333	0.990	1.0	90	91.0	16
07-Sep	0	15	6	3	2.000	0.990	1.0	90	91.0	24
	15	15	4	4	1.000	0.790	1.0	90	91.0	16
	300	15	4	8	0.500	0.790	1.0	90	91.0	16
	600	15	4	2	2.000	0.790	1.0	90	91.0	16
	1100	15	0	0	----	0.790	1.0	90	91.0	0
	1600	15	1	1	1.000	0.790	1.0	90	91.0	4
	2102	30	19	17	1.118	0.790	1.0	90	91.0	38

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Appendix E. (page 6 of 8).

Date	Time Start	Duration (min.)	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
08-Sep	30	15	9	8	1.125	0.790	1.0	90	91.0	36
	300	15	2	1	2.000	0.790	1.0	90	91.0	8
	600	15	9	7	1.286	0.790	1.0	90	91.0	36
	1100	30	18	73	0.247	0.790	1.0	90	91.0	36
	1605	15	3	14	0.214	0.790	1.0	90	91.0	12
	2100	15	4	3	1.333	0.790	1.0	90	91.0	16
09-Sep	0	30	25	22	1.136	0.790	1.0	90	91.0	50
	300	15	4	6	0.667	0.790	1.0	90	91.0	16
	600	30	11	11	1.000	0.790	1.0	90	91.0	22
	1100	15	1	1	1.000	0.790	1.0	90	91.0	4
	1600	15	5	6	0.833	0.790	1.0	90	91.0	20
	2105	30	23	23	1.000	0.790	1.0	90	91.0	46
10-Sep	0	30	18	17	1.059	0.790	1.0	90	91.0	36
	300	15	7	8	0.875	0.790	1.0	90	91.0	28
	600	30	19	18	1.056	0.790	1.0	90	91.0	38
	1104	15	6	6	1.000	0.790	1.0	90	91.0	24
	1605	15	0	0	---	0.790	1.0	90	91.0	0
	2100	15	4	3	1.333	0.790	1.0	90	91.0	16
11-Sep	30	15	6	8	0.750	0.790	1.0	90	91.0	24
	300	15	7	7	1.000	0.790	1.0	90	91.0	28
	600	15	7	7	1.000	0.790	1.0	90	91.0	28
	1103	15	2	2	1.000	0.790	1.0	90	91.0	8
	1616	15	2	2	1.000	0.790	1.0	100	101.0	8
	2100	15	1	1	1.000	0.790	1.0	100	101.0	4
12-Sep	0	15	4	5	0.800	0.790	1.0	100	101.0	16
	315	15	6	8	0.750	0.790	1.0	100	101.0	24
	600	30	20	21	0.952	0.790	1.0	100	101.0	40
	1114	30	20	16	1.250	0.790	1.0	100	101.0	40
	1145	15	7	6	1.167	0.666	1.0	100	101.0	28
	1600	15	2	3	0.667	0.666	1.0	100	101.0	8
	2100	15	3	4	0.750	0.666	1.0	100	101.0	12
13-Sep	5	30	29	32	0.906	0.666	1.0	100	101.0	58
	300	15	12	10	1.200	0.666	1.0	100	101.0	48
	600	15	9	12	0.750	0.667	1.0	100	101.0	36
	1102	15	4	3	1.333	0.667	1.0	100	101.0	16
	1600	15	7	8	0.875	0.667	1.0	100	101.0	28
	2100	15	8	8	1.000	0.667	1.0	100	101.0	32

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Date	Time Start	Duration (min.)	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
14-Sep	15	30	32	35	0.914	0.667	1.0	100	101.0	64
	300	30	55	64	0.859	0.667	1.0	100	101.0	110
	600	30	31	35	0.886	0.667	1.0	100	101.0	62
	1108	15	6	5	1.200	0.667	1.0	100	101.0	24
	1600	15	4	4	1.000	0.667	1.0	100	101.0	16
	2100	30	40	45	0.889	0.667	1.0	100	101.0	80
15-Sep	0	15	5	4	1.250	0.667	1.0	100	101.0	20
	300	30	35	41	0.854	0.667	1.0	100	101.0	70
	600	30	34	39	0.872	0.667	1.0	100	101.0	68
	1100	15	0	0	----	0.667	1.0	100	101.0	0
	1600	15	2	2	1.000	0.667	1.0	100	101.0	8
	2100	30	33	41	0.805	0.667	1.0	100	101.0	66
16-Sep	15	30	50	51	0.980	0.667	1.0	100	101.0	100
	300	30	30	33	0.909	0.667	1.0	100	101.0	60
	600	30	47	45	1.044	0.667	1.0	100	101.0	94
	1142	15	7	5	1.400	0.667	1.0	100	101.0	28
	1600	15	4	4	1.000	0.667	1.0	100	101.0	16
	2115	15	8	6	1.333	0.667	1.0	100	101.0	32
17-Sep	0	30	45	48	0.938	0.667	1.0	100	101.0	90
	300	30	47	51	0.922	0.667	1.0	100	101.0	94
	600	15	5	6	0.833	0.667	1.0	100	101.0	20
	1117	15	1	1	1.000	0.667	1.0	100	101.0	4
	1600	15	5	5	1.000	0.667	1.0	100	101.0	20
	2115	30	75	78	0.962	0.667	1.0	100	101.0	150
18-Sep	15	30	27	32	0.844	0.667	1.0	100	101.0	54
	300	30	85	93	0.914	0.667	1.0	100	101.0	170
	600	30	32	27	1.185	0.667	1.0	100	101.0	64
	1100	15	2	3	0.667	0.667	1.0	100	101.0	8
	1130	30	25	28	0.893	0.667	1.0	100	101.0	50
	1600	15	3	2	1.500	0.667	1.0	100	101.0	12
	2100	30	25	31	0.806	0.667	1.0	100	101.0	50
19-Sep	0	30	72	85	0.847	0.667	1.0	100	101.0	144
	300	30	73	77	0.948	0.667	1.0	100	101.0	146
	600	30	42	43	0.977	0.667	1.0	100	101.0	84
	1104	15	2	2	1.000	0.667	1.0	100	101.0	8
	1606	30	33	34	0.971	0.667	1.0	100	101.0	66
	2100	15	9	10	0.900	0.667	1.0	100	101.0	36

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Appendix E. (page 8 of 8).

Date	Time Start	Duration (min.)	Scope Count	Sonar Count	Adjustment Factor	PRR	Dead Range	Ctng Range	Total Range	Passage Rate (fish/hour)
20-Sep	0	30	31	33	0.939	0.667	1.0	100	101.0	62
	300	30	31	32	0.969	0.667	1.0	100	101.0	62
	600	30	45	52	0.865	0.667	1.0	100	101.0	90
	1102	15	31	70	0.443	0.667	1.0	100	101.0	124
	1119	30	29	30	0.967	0.900	1.0	100	101.0	58
	1612	30	33	32	1.031	0.900	1.0	100	101.0	66
	2115	30	18	20	0.900	0.900	1.0	100	101.0	36
21-Sep	0	15	8	9	0.889	0.900	1.0	100	101.0	32
	300	30	37	28	1.321	0.900	1.0	100	101.0	74
	600	15	6	5	1.200	0.900	1.0	100	101.0	24
	1111	15	6	8	0.750	0.900	1.0	100	101.0	24
	1600	15	7	6	1.167	0.900	1.0	100	101.0	28
	2100	15	3	3	1.000	0.900	1.0	100	101.0	12
22-Sep	0	15	2	3	0.667	0.900	1.0	100	101.0	8
	314	30	46	39	1.179	0.900	1.0	100	101.0	92
	345	30	41	49	0.837	0.780	1.0	100	101.0	82
	600	30	25	31	0.806	0.780	1.0	100	101.0	50
	1103	15	2	5	0.400	0.780	1.0	100	101.0	8
	1125	15	0	0	----	0.900	1.0	100	101.0	0
	1600	15	8	10	0.800	0.900	1.0	100	101.0	32
	2100	15	8	9	0.889	0.900	1.0	100	101.0	32
23-Sep	0	15	7	8	0.875	0.900	1.0	100	101.0	28
	300	30	22	20	1.100	0.900	1.0	100	101.0	44
	600	15	8	10	0.800	0.900	1.0	100	101.0	32
	1100	15	2	3	0.667	0.900	1.0	100	101.0	8
	1600	15	6	5	1.200	0.900	1.0	100	101.0	24
	2115	15	8	9	0.889	0.900	1.0	100	101.0	32
24-Sep	15	15	9	7	1.286	0.900	1.0	100	101.0	36
	300	30	25	24	1.042	0.900	1.0	100	101.0	50
	600	30	32	35	0.914	0.900	1.0	100	101.0	64
	1105	15	0	0	----	0.900	1.0	100	101.0	0
	1600	15	0	0	----	0.900	1.0	100	101.0	0
	2300	30	36	34	1.059	0.900	1.0	100	101.0	72
Total	293	5,595	3,210	3,932	0.816					

Appendix F. Age composition estimates of Sheenjek River fall chum salmon, 1974 - 2002.

Year [a]	Sample (readable)	Age 3	Age 4	Age 5	Age 6	Estimated Escapement
1974 [b]	136	0.669	0.301	0.029	0.000	89,966
1975 [b]	197	0.036	0.949	0.015	0.000	173,371
1976 [b]	118	0.017	0.441	0.542	0.000	26,354
1977 [b]	178	0.112	0.725	0.163	0.000	45,544
1978 [b]	190	0.079	0.821	0.100	0.000	32,449
1979	none					91,372
1980	none					28,933
1981 [c]	340	0.029	0.850	0.118	0.003	74,560
1982 [c]	109	0.030	0.470	0.490	0.010	31,421
1983 [c]	108	0.065	0.870	0.065	0.000	49,392
1984 [d]	297	0.101	0.805	0.094	0.000	27,130
1985 [d]	508	0.012	0.927	0.061	0.000	152,768
1986 [d]	442	0.081	0.412	0.500	0.007	84,207
1987 [d]	431	0.021	0.898	0.072	0.009	153,267
1988 [d, e]	120	0.025	0.683	0.292	0.000	45,206
1989 [d, e]	154	0.052	0.766	0.169	0.013	99,116
1990 [d]	143	0.028	0.706	0.252	0.014	77,750
1991 [d]	147	0.000	0.592	0.395	0.014	86,496
1992 [d]	134	0.000	0.179	0.806	0.015	78,808
1993 [d, e]	192	0.005	0.640	0.339	0.016	42,922
1994 [d]	173	0.012	0.561	0.405	0.023	153,000
1995 [d]	166	0.012	0.542	0.386	0.060	235,000
1996 [d]	191	0.016	0.330	0.618	0.037	248,000
1997	none					80,423
1998	only 3 fish					33,058
1999	none					14,229
2000	none					30,084
2001 [f]	71	0.000	0.352	0.648	0.000	53,932
2002 [g]	31	0.000	0.613	0.387	0.000	31,642
Avg 1974-02		0.061	0.628	0.302	0.010	81,738
Avg 1974-85		0.115	0.716	0.168	0.001	68,605
Avg 1986-02		0.019	0.560	0.405	0.016	94,719
Even Years		0.088	0.527	0.376	0.009	67,867
Odd years		0.031	0.737	0.221	0.010	96,599

[a] Age determination from scales for years 1974-1985; and from vertebrae 1986-2002.
[b] Carcass samples from spawning grounds.
[c] Escapement samples taken with 5-7/8 inch gillnets at rkm 10.
[d] Escapement samples taken with beach seine rkm 5-20.
[e] Escapement samples were predominantly taken late in run.
[f] 68 carcass samples and 5 beach seine samples collected between rkm 11 and 25.
[g] 28 beach seine samples collected at rkm 13 and 1 carcass collected at rkm 10.

Appendix G. Sonar-estimated escapement of fall chum salmon in the Sheenjek River, 1986-2002.

Date	1986	1987	1988	1989	1990	1991	1992	1993
30-Jul								
31-Jul								
01-Aug								
02-Aug								
03-Aug								
04-Aug								
05-Aug								
06-Aug								
07-Aug								
08-Aug								45
09-Aug	I	I	I	I	I	255	136	95
10-Aug	I	I	I	I	I	301	172	256
11-Aug	I	I	I	I	I	179	102	143
12-Aug	I	I	I	I	I	173	272	217
13-Aug	I	I	I	I	I	178	216	227
14-Aug	I	I	I	I	I	282	337	175
15-Aug	I	I	I	I	I	551	670	291
16-Aug	1,010 *	I	I	I	I	521	571	346
17-Aug	68	I	I	I	I	418	1,100	567
18-Aug	345	I	I	I	I	291	1,370	243
19-Aug	769	I	I	I	I	668	1,003	316
20-Aug	1,576	I	4,340 *	I	I	446	2,147	466
21-Aug	1,179	I	961	I	15,550 *	1,012	1,767	117
22-Aug	3,023	I	1,027	I	1,714	1,990	1,153	124
23-Aug	1,177	I	884	20,000 *	1,825	1,754	1,189	137
24-Aug	1,733	13,181 *	744	2,685	1,940	889	1,390	177
25-Aug	3,374	168	810	2,321	1,628	1,091	1,147	156
26-Aug	4,075	314	1,528	1,392	1,047	1,084	893	288
27-Aug	3,712	795	1,209	1,129	1,055	1,846	1,032	208
28-Aug	4,633	951	1,087	1,009	1,337	1,508	778	296
29-Aug	5,130	993	756	732	1,605	1,196	463	369
30-Aug	4,336	1,400	914	1,263	881	905	943	647
31-Aug	3,889	1,639	1,312	933	1,609	1,176	840	999
01-Sep	2,101	3,957	1,548	1,598	1,370	2,164	835	1,045
02-Sep	2,250	3,295	1,492	1,739	1,695	1,749	830	632
03-Sep	1,819	7,585	2,203	1,739	1,002	1,858	1,217	2,092
04-Sep	2,406	11,386	1,991	2,819	1,158	2,026	2,023	2,557
05-Sep	1,685	10,962	1,309	2,371	958	2,476	2,093	2,097
06-Sep	2,263	5,439	1,286	2,836	1,338	1,341	3,154	1,673
07-Sep	2,849	10,182	1,542	4,210	1,239	3,490	4,200	2,414
08-Sep	2,760	11,122	1,297	3,381	1,071	2,680	3,002	2,720
09-Sep	2,469	8,487	1,443	4,838	1,411	4,201	4,274	1,300
10-Sep	1,131	5,961	1,073	4,031	454	3,541	3,209	580
11-Sep	1,461	4,882	696	3,331	1,746	2,236	3,815	401
12-Sep	2,500	6,294	340	3,414	1,726	3,136	3,816	463
13-Sep	1,751	5,831	673	3,227	1,383	3,139	4,047	373
14-Sep	2,866	4,485	702	2,797	2,136	3,143	6,347	331
15-Sep	2,290	3,963	1,037	2,027	2,060	4,823	4,289	197
16-Sep	1,099	4,118	1,275	2,498	2,179	4,240	3,232	407
17-Sep	1,488	4,763	1,943	3,033	2,887	2,729	2,473	1,176
18-Sep	1,481	4,326	1,677	2,090	1,909	2,734	2,138	1,053
19-Sep	1,544	2,655	1,209	1,839	2,028	3,119	2,406	1,159
20-Sep	679	3,160	1,151	2,221	2,372	3,319	1,007	1,192
21-Sep	704	3,225	716	1,273	2,444	2,461	early	1,382
22-Sep	577	1,988	743	1,384	2,667	1,924	freezeup	2,005
23-Sep	587	2,879	583	2,454	1,348	2,071		1,801
24-Sep	653	3,324	522	2,965	1,819	1,430		1,655
25-Sep			365	2,072	1,923			1,083
26-Sep			344		1,202			1,158
27-Sep			319		1,478			568
28-Sep					798			497
29-Sep								
30-Sep								
Totals	84,207	153,267	45,206	99,116	77,750	86,496	78,808	42,922

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Appendix G. (page 2of 2)

Date	1994	1995	1996	1997	1998	1999	2000	2001	2002
30-Jul			670						
31-Jul			706						
01-Aug			341						
02-Aug			793						
03-Aug			483						
04-Aug			377						
05-Aug			408						
06-Aug			724						
07-Aug	146		918						
08-Aug	75		1,254				19		
09-Aug	112		930	114			34		602
10-Aug	38	994	963	248		32	133		756
11-Aug	214	882	479	332		60	160	49	656
12-Aug	343	468	315	306		37	194	78	328
13-Aug	328	344	313	421		76	237	79	381
14-Aug	215	339	993	473		41	179	73	439
15-Aug	263	1,043	782	420		43	203	121	396
16-Aug	333	863	733	334		70	342	126	449
17-Aug	378	891	602	347	16	86	234	90	360
18-Aug	524	1,172	734	307	98	101	487	397	262
19-Aug	497	1,656	733	438	61	250	578	948	395
20-Aug	257	2,105	1,662	354	33	217	487	584	179
21-Aug	394	2,832	1,394	295	25	224	333	313	333
22-Aug	642	2,677	1,178	506	77	59	318	507	343
23-Aug	1,677	3,323	2,472	688	38	138	341	689	220
24-Aug	1,033	6,301	11,459	996	43	279	319	884	139
25-Aug	849	4,743	9,966	1,059	95	730	394	1030	370
26-Aug	791	4,445	7,034	1,179	93	395	499	967	300
27-Aug	2,934	6,318	4,345	2,329	59	643	597	666	244
28-Aug	3,677	4,839	5,778	2,320	114	476	512	850	488
29-Aug	4,082	6,843	11,457	1,884	47	410	552	985	893
30-Aug	4,487	7,436	12,340	2,067	145	247	732	976	373
31-Aug	5,472	6,517	12,122	2,250	274	207	691	885	733
01-Sep	6,912	8,782	7,597	2,453	246	115	662	1481	774
02-Sep	7,196	5,856	6,326	2,616	234	164	783	1923	657
03-Sep	5,918	7,049	8,457	2,799	117	203	796	1374	542
04-Sep	3,666	4,183	5,115	3,404	381	327	1,023	1235	820
05-Sep	2,832	4,525	5,214	5,102	118	186	961	1968	429
06-Sep	2,953	6,084	5,763	2,761	277	423	599	2574	838
07-Sep	2,928	6,852	7,871	2,904	354	418	1,073	1537	343
08-Sep	5,587	6,318	6,333	4,542	590	742	1,518	1378	466
09-Sep	2,398	5,403	3,718	2,849	413	555	783	3098	676
10-Sep	2,341	4,857	4,364	1,995	416	594	856	2975	567
11-Sep	3,382	6,758	7,409	1,971	594	514	641	3286	376
12-Sep	2,796	6,597	4,735	3,123	732	478	710	3536	670
13-Sep	3,066	8,561	6,974	3,602	1,348	509	11,233[c]	2679	841
14-Sep	3,294	6,184	5,944	3,093	1,129	343		2130	1153
15-Sep	3,522	10,161	5,406	3,294	1,201	509		1833	928
16-Sep	4,764	9,026	7,871	2,376	2,610	303		900	1247
17-Sep	4,413	9,097	11,181	2,379	2,492	458		1402	1124
18-Sep	3,249	8,525	7,858	2,116	2,607	342		420	1588
19-Sep	6,500	8,468	10,474	3,096	2,526	294		1110	2606
20-Sep	7,583	9,065	6,733	1,612	3,692	298		513	1088
21-Sep	5,287	5,598	6,178	1,612	2,756	289		1017	1199
22-Sep	6,520	3,945	3,924	2,249	3,120	531		1018	816
23-Sep	5,153	4,518	4,486	2,028	1,594	456		622	879
24-Sep	4,523	6,832	1,902		811				769
25-Sep	3,697	6,857			329				
26-Sep	3,458				430				
27-Sep	3,600				487				
28-Sep	4,062				736				
29-Sep					587				
30-Sep					661				
Totals	150,565	241,355	246,889	80,423	33,058	14,229	30,084	53,932	31642

[a] Early portion of Sheenjek River fall chum salmon run estimated from run timing and entry pattern observed in the Chandalar River (Barton 1995).
[b] Early portion of Sheenjek River fall chum salmon run estimated from aerial survey (Barton 1995).
[c] Late portion of Sheenjek River fall chum salmon run estimated from average run time data observed in the Sheenjek River, 1986 - 1999 (Barton 2002).

Appendix H. Cumulative proportion of Sheenjek River sonar counts, 1986-2002.

Date	1986	1987	1988	1989	1990	1991	1992	1993
30-Jul								
31-Jul								
01-Aug								
02-Aug								
03-Aug								
04-Aug								
05-Aug								
06-Aug								
07-Aug								
08-Aug								0.00
09-Aug						0.00	0.00	0.00
10-Aug						0.00	0.00	0.01
11-Aug						0.01	0.01	0.01
12-Aug						0.01	0.01	0.02
13-Aug						0.01	0.01	0.03
14-Aug						0.01	0.02	0.03
15-Aug						0.02	0.02	0.03
16-Aug	0.01					0.03	0.05	0.04
17-Aug	0.01					0.03	0.05	0.05
18-Aug	0.02					0.04	0.07	0.06
19-Aug	0.03					0.04	0.08	0.06
20-Aug	0.04		0.10			0.05	0.11	0.07
21-Aug	0.06		0.12		0.20	0.06	0.13	0.08
22-Aug	0.09		0.14		0.22	0.08	0.15	0.08
23-Aug	0.11		0.16	0.20	0.25	0.10	0.16	0.08
24-Aug	0.13	0.09	0.18	0.23	0.27	0.12	0.18	0.09
25-Aug	0.15	0.09	0.19	0.25	0.29	0.13	0.19	0.09
26-Aug	0.25	0.09	0.23	0.27	0.30	0.15	0.21	0.10
27-Aug	0.29	0.09	0.25	0.28	0.32	0.17	0.22	0.10
28-Aug	0.35	0.10	0.28	0.29	0.34	0.19	0.23	0.11
29-Aug	0.41	0.11	0.30	0.30	0.36	0.21	0.23	0.12
30-Aug	0.46	0.12	0.32	0.31	0.37	0.22	0.25	0.13
31-Aug	0.51	0.13	0.35	0.32	0.39	0.24	0.26	0.16
01-Sep	0.53	0.15	0.38	0.33	0.41	0.26	0.27	0.18
02-Sep	0.56	0.17	0.42	0.35	0.43	0.28	0.28	0.19
03-Sep	0.58	0.22	0.46	0.37	0.44	0.30	0.29	0.24
04-Sep	0.61	0.30	0.51	0.40	0.46	0.32	0.32	0.30
05-Sep	0.63	0.37	0.54	0.42	0.47	0.35	0.35	0.33
06-Sep	0.66	0.40	0.57	0.45	0.49	0.37	0.39	0.39
07-Sep	0.69	0.47	0.60	0.50	0.50	0.41	0.44	0.45
08-Sep	0.72	0.54	0.63	0.53	0.52	0.44	0.48	0.51
09-Sep	0.75	0.60	0.66	0.58	0.54	0.49	0.53	0.54
10-Sep	0.77	0.64	0.68	0.62	0.55	0.53	0.57	0.55
11-Sep	0.78	0.67	0.70	0.66	0.57	0.55	0.62	0.56
12-Sep	0.81	0.71	0.71	0.69	0.59	0.59	0.67	0.57
13-Sep	0.83	0.75	0.72	0.72	0.61	0.62	0.72	0.58
14-Sep	0.87	0.78	0.74	0.75	0.64	0.66	0.80	0.59
15-Sep	0.90	0.80	0.76	0.77	0.67	0.72	0.86	0.60
16-Sep	0.91	0.83	0.79	0.80	0.70	0.77	0.90	0.61
17-Sep	0.93	0.86	0.83	0.83	0.73	0.80	0.93	0.63
18-Sep	0.94	0.89	0.87	0.85	0.76	0.83	0.96	0.66
19-Sep	0.96	0.90	0.90	0.87	0.78	0.87	0.98	0.69
20-Sep	0.97	0.93	0.92	0.89	0.82	0.91	1.00	0.73
21-Sep	0.98	0.95	0.94	0.90	0.85	0.93		0.80
22-Sep	0.99	0.96	0.95	0.92	0.88	0.96		0.84
23-Sep	0.99	0.98	0.97	0.94	0.90	0.98		0.88
24-Sep	1.00	1.00	0.98	0.97	0.93	1.00		0.92
25-Sep			0.99	1.00	0.95			0.95
26-Sep			0.99		0.97			0.98
27-Sep			1.00		0.99			0.99
28-Sep					1.00			1.00
29-Sep								
30-Sep								

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Appendix H. (page 2 of 2)

Date	1994	1995	1996	1997	1998	1999	2000	2001	2002	1986-01 average
30-Jul			0.00							
31-Jul			0.01							
01-Aug			0.01							
02-Aug			0.01							
03-Aug			0.01							
04-Aug			0.02							
05-Aug			0.02							
06-Aug			0.02							
07-Aug	0.00		0.02				0.00			
08-Aug	0.00	0.00	0.03	0.00	0.00		0.00			
09-Aug	0.00	0.00	0.03	0.00	0.00		0.00		0.02	
10-Aug	0.00	0.00	0.04	0.00	0.00	0.00	0.01		0.04	
11-Aug	0.00	0.01	0.04	0.01	0.00	0.01	0.01	0.00	0.06	
12-Aug	0.01	0.01	0.04	0.01	0.00	0.01	0.02	0.00	0.08	
13-Aug	0.01	0.01	0.04	0.02	0.00	0.01	0.03	0.00	0.09	
14-Aug	0.01	0.01	0.05	0.02	0.00	0.02	0.03	0.01	0.11	
15-Aug	0.01	0.02	0.05	0.03	0.00	0.02	0.04	0.01	0.12	
16-Aug	0.01	0.02	0.05	0.04	0.00	0.03	0.05	0.01	0.13	
17-Aug	0.02	0.02	0.06	0.04	0.00	0.03	0.06	0.01	0.14	
18-Aug	0.02	0.03	0.06	0.04	0.00	0.04	0.08	0.02	0.15	
19-Aug	0.02	0.04	0.06	0.05	0.01	0.06	0.10	0.04	0.17	
20-Aug	0.02	0.04	0.07	0.05	0.01	0.07	0.11	0.05	0.17	
21-Aug	0.03	0.06	0.07	0.06	0.01	0.09	0.12	0.06	0.18	
22-Aug	0.03	0.07	0.08	0.06	0.01	0.09	0.13	0.07	0.19	
23-Aug	0.04	0.08	0.09	0.07	0.01	0.10	0.14	0.08	0.20	
24-Aug	0.05	0.11	0.14	0.08	0.01	0.12	0.15	0.09	0.20	0.11
25-Aug	0.06	0.13	0.18	0.10	0.02	0.17	0.17	0.11	0.21	0.13
26-Aug	0.06	0.15	0.20	0.11	0.02	0.20	0.18	0.13	0.23	0.14
27-Aug	0.08	0.17	0.22	0.14	0.02	0.23	0.20	0.15	0.23	0.19
28-Aug	0.11	0.19	0.25	0.17	0.02	0.30	0.22	0.17	0.25	0.21
29-Aug	0.13	0.22	0.29	0.19	0.02	0.32	0.24	0.18	0.27	0.22
30-Aug	0.16	0.25	0.34	0.22	0.03	0.34	0.26	0.20	0.29	0.23
31-Aug	0.20	0.28	0.39	0.25	0.04	0.36	0.28	0.22	0.32	0.26
01-Sep	0.24	0.31	0.42	0.28	0.04	0.36	0.30	0.25	0.34	0.30
02-Sep	0.29	0.34	0.45	0.31	0.05	0.38	0.33	0.28	0.36	0.32
03-Sep	0.33	0.37	0.48	0.34	0.06	0.39	0.36	0.31	0.38	0.35
04-Sep	0.36	0.38	0.50	0.39	0.06	0.41	0.39	0.33	0.40	0.38
05-Sep	0.37	0.40	0.52	0.43	0.07	0.43	0.42	0.37	0.42	0.41
06-Sep	0.39	0.43	0.54	0.46	0.08	0.46	0.44	0.42	0.44	0.43
07-Sep	0.42	0.46	0.57	0.50	0.08	0.48	0.48	0.45	0.46	0.47
08-Sep	0.44	0.48	0.60	0.56	0.10	0.54	0.53	0.51	0.47	0.51
09-Sep	0.46	0.50	0.61	0.59	0.11	0.58	0.55	0.57	0.49	0.54
10-Sep	0.48	0.53	0.63	0.62	0.13	0.62	0.58	0.63	0.51	0.57
11-Sep	0.50	0.55	0.66	0.64	0.14	0.65	0.60	0.67	0.52	0.60
12-Sep	0.52	0.58	0.68	0.67	0.17	0.69	0.63	0.74	0.54	0.63
13-Sep	0.54	0.61	0.71	0.72	0.21	0.73	0.57[d]	0.79	0.57	0.66[e]
14-Sep	0.56	0.63	0.73	0.75	0.24	0.75	↓	0.83	0.61	0.69
15-Sep	0.58	0.68	0.75	0.80	0.28	0.77	↓	0.86	0.64	0.72
16-Sep	0.62	0.71	0.79	0.83	0.36	0.80	↓	0.88	0.68	0.75
17-Sep	0.64	0.73	0.82	0.85	0.44	0.83	↓	0.91	0.72	0.79
18-Sep	0.67	0.79	0.86	0.88	0.52	0.86	↓	0.92	0.77	0.82
19-Sep	0.71	0.82	0.91	0.91	0.59	0.88	↓	0.94	0.83	0.85
20-Sep	0.76	0.85	0.93	0.93	0.68	0.90	↓	0.95	0.88	0.88
21-Sep	0.79	0.89	0.96	0.95	0.76	0.93	↓	0.97	0.92	0.90
22-Sep	0.84	0.92	0.97	0.97	0.82	0.97	↓	0.99	0.95	0.93
23-Sep	0.87	0.95	0.99	1.00	0.87	1.00	↓	1.00	0.98	0.95
24-Sep	0.90	0.97	1.00		0.90		↓		1.00	0.96
25-Sep	0.93	1.00			0.91		↓			0.96
26-Sep	0.95				0.93					
27-Sep	0.97				0.94					
28-Sep	1.00				0.96					
29-Sep					0.98					
30-Sep					1.00					

[a] Early portion of Sheenjek River fall chum salmon run estimated from run timing and entry pattern observed in the Chandalar River (Barton 1995).

[b] Early portion of Sheenjek River fall chum salmon run estimated from aerial survey (Barton 1995).

[c] Interquartile range and median day of passage (◻) are shown for each year.

[d] Late portion of Sheenjek River fall chum salmon run estimated from average run time data observed in the Sheenjek River, 1986 - 1999 (Barton 2002).

[e] September 13 to September 25, 2000 not used in calculating 1986-2001 average.